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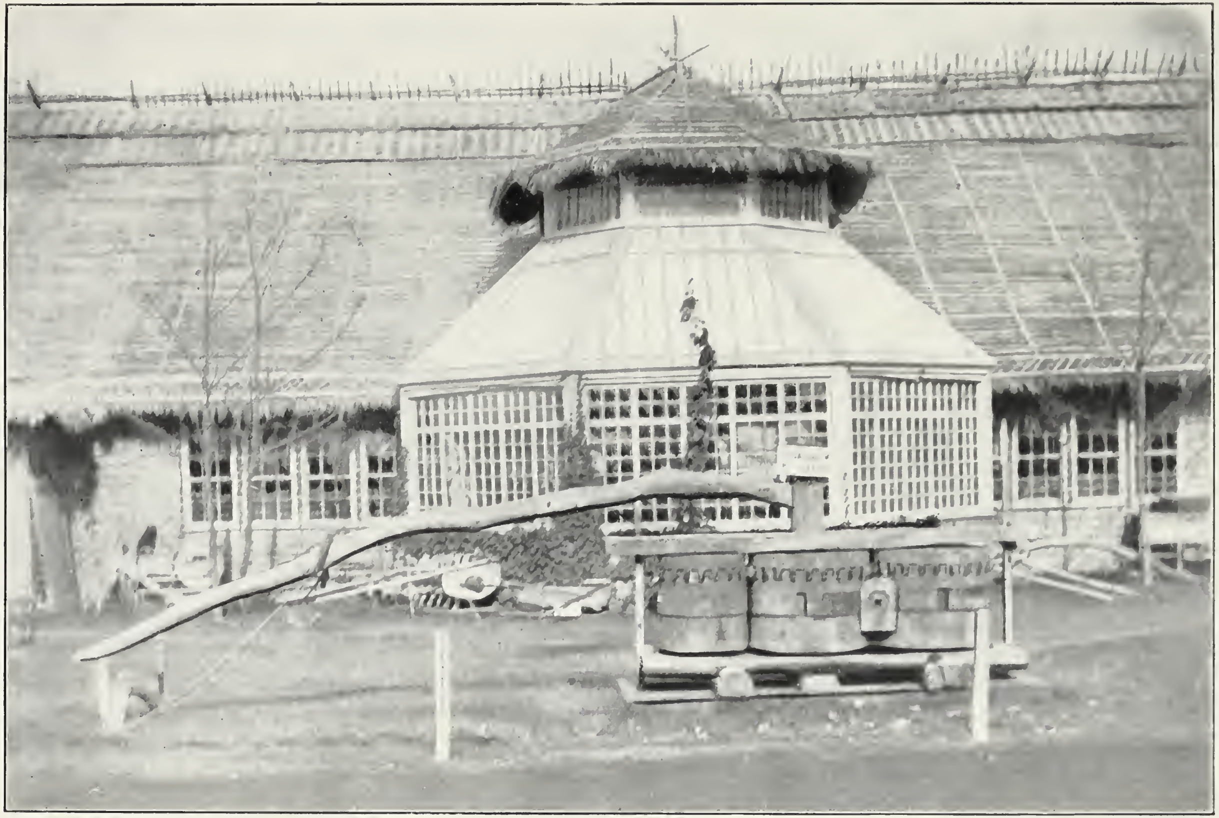
PLATE I.



PHILIPPINE CANE MILL, ST. LOUIS EXPOSITION.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY—BULLETIN NO. 93.
H. W. WILEY, Chief of Bureau.

EXPERIMENTS IN THE CULTURE OF SUGAR CANE AND ITS MANUFACTURE INTO TABLE SIRUP.

A REPORT ON THE INVESTIGATIONS CONDUCTED AT WAYCROSS AND CAIRO, GA., IN 1903 AND 1904.

BY

H. W. WILEY,
CHIEF OF THE BUREAU OF CHEMISTRY,

WITH THE COLLABORATION OF G. L. SPENCER, W. B. RODDENBERY, G. R. YOUMANS, AND ARTHUR GIVEN, OF THE BUREAU OF CHEMISTRY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING

A REPORT ON EXPERIMENTS IN THE CULTURE OF SUGAR CANE AND ITS MANUFACTURE INTO TABLE SIRUP IN 1903 AND 1904.

MARCH 2, 1905.—Read, ordered printed, and referred to the Committee on Agriculture.

To the Senate and House of Representatives:

I transmit herewith, for the information of the Congress, a Report on Sugar-Cane Experiments, 1903 and 1904. The attention of the Congress is respectfully invited to the accompanying letter of the Secretary of Agriculture recommending that 10,000 copies of the report be printed for the use of the Department of Agriculture in addition to such number as may be desired for the use of the Senate and House of Representatives.

THEODORE ROOSEVELT.

THE WHITE HOUSE,
March 2, 1905.

LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., February 28, 1905.

MR. PRESIDENT: I have the honor to transmit herewith for your information and that of the Congress of the United States a Report on Sugar-Cane Experiments, 1903 and 1904, conducted by the Bureau of Chemistry of this Department by authority of Congress. The investigations, the details and results of which are given in the report, were conducted chiefly in the State of Georgia, and were directed to the study of the product from sugar cane.

In view of the interest in this subject throughout the South, I respectfully recommend that 10,000 copies of the report be printed for the use of this Department in addition to the number which Congress may, in its wisdom, order for the use of the members thereof.

I have the honor to remain, Mr. President, very respectfully,

JAMES WILSON,
Secretary.

The PRESIDENT,
The White House.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., February 27, 1905.

SIR: I have the honor to submit for your approval the report for 1903 and 1904 on the experimental work, agricultural, technical, and chemical, conducted under the direction of this Bureau in accordance with the instructions of Congress, in growing sugar cane and manufacturing the same into table sirup, with the recommendation that the same be transmitted to the President and the Congress of the United States for their information.

Respectfully,

H. W. WILEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary.

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EXPERIMENTS IN THE CULTURE OF SUGAR CANE AND ITS MANUFACTURE INTO TABLE SIRUP.

ORGANIZATION AND OBJECTS OF THE INVESTIGATION.

In the act making appropriations for the Department of Agriculture, approved March 3, 1903, the following language is found:

> To investigate the chemical composition of sugar-producing plants in the United States and its possessions, and, in collaboration with the Weather Bureau and agricultural experiment stations, to study the effects of environment upon the chemical composition of sugar-producing plants, especially with reference to their content of available sugar, seventy thousand five hundred dollars: *Provided*, That fifteen thousand dollars thereof shall be used exclusively for the purpose of investigating, determining, and reporting the proper treatment and process in order to secure uniform grade and quality of first-class table sirup, of which sum ten thousand dollars shall be immediately available.

In the act making appropriations for the Department of Agriculture, approved April 23, 1904, the following language occurs:

> *And provided further*, That fifteen thousand dollars thereof shall be used exclusively for the purpose of investigating, determining, and reporting the proper treatment and process in order to secure uniform grade and quality of first-class table sirup; and the Secretary of Agriculture shall report to Congress at its next session the result of said investigation.

In harmony with the authority above conferred operations were begun during the fiscal year ended June 30, 1904, and have been continued during the fiscal year ending June 30, 1905, to carry on the work thus authorized by Congress. After a careful study of the localities in which it seemed advisable to establish the experimental work, the city of Waycross, Ga., was selected as being most satisfactory both by reason of its geographic position and its easy access by means of numerous lines of railway. The citizens of Waycross offered the free use of land for the experimental purposes, also agreeing to provide the necessary cane, and contracts were entered into to secure the above-named grants. Specifications were drawn by Mr. G. L. Spencer, an expert connected with this Department, for the erection of an experimental sugar mill with all necessary appliances. Contracts were awarded for the building of the mill, the erection of the necessary buildings, and the furnishing of other supplies. In order that additional information respecting the character of the cane best suited for the manufacture of table sirup might be supplied, arrangements were made with Mr. W. B. Roddenbery, of Cairo, Ga., to grow small experimental plats of cane in order to determine what effect different kinds and degrees of fertilization might have upon the yield of cane and the character of the juice.

The work of preparation was pushed with all possible speed, but, owing to the late day at which the appropriation became available and the necessary time required to secure competitive bids for all the apparatus and work, it was found impossible to complete the experimental factory in proper time to secure a full study of the various problems involved. After many vexatious delays, however, the experimental factory, although not wholly completed, was put in operation late in the season of 1903 and a considerable amount of experimental data was obtained. The principal value of the first year's work was in pointing out the necessary enlargements and improvements of the appliances which had been secured. When the second year's appropriation became available the work of completing the factory was pushed forward with vigor, and by the time the cane was ready for manufacture into sirup in the autumn of 1904 all the necessary preparations had been made.

In the following report the data—cultural, chemical, and technical—are first given for the campaign of 1903 and afterwards for the campaign of 1904. The data are arranged in the following order: (1) The cultural data secured from the experimental plats; (2) the technical or manufacturing data secured in the operation of the experimental factory; and (3) the chemical data obtained in the analysis of the cane juices and of the finished products. All the data which were secured are offered in this report, both of a favorable and unfavorable nature, in order that the full magnitude of the problem may be fully understood and that the conclusions which have been reached by a study of the data may rest upon facts which are open to the study of all.

THE AGRICULTURAL PROBLEM.

Of the principal problems presented for solution the first is the agricultural problem. This relates to the character of the soil on which the canes are grown in the regions of the South Atlantic and the Gulf, where the climate is favorable to the production of sugar cane. The soil of these localities, as is well known, is composed largely of sand, and the native forest which once covered them was almost exclusively of pine. The pine tree is one which grows with perhaps less drain upon the elements of the soil than almost any other forest growth. The quantity of organic material, however, which the pine tree deposits upon the soil is perhaps less than that of almost any other forest growth. Hence it happens that the virgin soil of these regions is not only deficient in the mineral elements of the plant food, owing to the fact that they are composed chiefly of siliceous material, but also in material of organic origin, namely, humus. The natural fertility which these soils have when first cultivated is, therefore, rapidly exhausted by the ordinary system of cropping which has been practiced. It is a fact which has been established by observation and experiment that soils which are somewhat deficient in fertility produce crops of exceptionally fine texture and character. This is due probably to the fact that an overabundance of plant food forces a plant to a somewhat coarse as well as vigorous growth, thus modifying, to a certain extent, the quality and flavor of the food products which grow upon it. It is probable, therefore, that soil of limited fertility, such as the sandy soils of the regions mentioned, while producing a smaller crop of sugar cane, will give one of greater purity, and therefore of greater suitability for the manufacture of table sirup, than could be grown on the rich alluvial soils of Mississippi and other regions. The high purity of the juices of many of the canes grown in this region attest the accuracy of this theory.

It is evident that the success of the industry of making table sirup from sugar cane must rest first of all upon agricultural conditions, and hence the necessity of studying these conditions as precedent to the solution of other and more strictly technical problems. The results of the experimental work show that without judicious fertilization the tonnage of sugar cane produced per acre is very small, falling sometimes to 5 tons and even less per acre. On the other hand, by judicious fertilization, by proper rotation of crops, and by the growth of cowpeas and other leguminous plants which help to furnish nitrogen for succeeding crops, it is possible on the sandy soils above described to secure very fair yields of sugar cane, 39 tons per acre having been harvested in one instance.

The results of the agricultural experiments show that it is comparatively easy on the sandy soils mentioned to produce crops of from 15 to 25 tons per acre. The details of the culture and the fertilization are fully set forth in the data which form a part of the present report.

PROBLEMS IN MANUFACTURING.

The next problem, and one of the most important which was set for solution, was that of extracting a larger proportion of the juice of the cane than was customarily done in the small mills used by the farmers for that purpose. No accurate records had been kept of the degree of extraction which these small mills secured, but it is evident from all of the facts that can be gathered that often not more than half of the juice which was present in the cane was obtained by the ordinary methods of extraction. This is a fact of the utmost importance to economical agriculture, since it is evidently most wasteful for the farmer to produce by scientific methods and hard labor a large crop, half of which is wasted in the process of manufacture. It was therefore determined to attempt to apply to the sirup manufacturing in a small way the principles which had been so successfully applied in the manufacture of sugar on a large scale, namely, the introduction of multiple rolls which would subject the canes to repeated pressures.

As is well known, in the old-fashioned mills, consisting of two rolls, the cane was subject to but one pressure. In the mills which are in more common use in recent times, consisting of 3 rolls, the cane is subjected to the double pressure. It was determined, therefore, to erect two mills tandem, each mill consisting of 3 rolls. In this manner the canes passing through these two mills were subjected to four pressures. The results of this arrangement were entirely satisfactory, since the data showed that the extraction secured by the 6-roll mill ranged between 70 and 75 per cent of the total weight of the cane. When it is remembered that in the very strongest mills which are used in large sugar factories, consisting often of 9 rolls, giving 6 different pressures, the extraction does not rise much above 80 per cent, if any, the results with the two small 3-roll mills used in the experiments at Waycross must be considered entirely successful.

The second manufacturing problem which was under investigation related to the possibility of properly clarifying the cane juices so as to make a reasonably light-colored and bright sirup without the addition of any chemical substance whatever, relying solely upon heat and mechanical skimming to secure clarification. The reason for studying this problem is not difficult to discern. The value of a table sirup depends (1) upon its palatability and nutritive properties, and (2) upon its freedom from substances injurious to health. Most of the substances which are employed for the chemical clarification of cane juices are open to the suspicion of being to some extent at least injurious to health. Where the object is the manufacture of sugar only, the use of such clarifying agents is wholly unobjectionable, because scarcely a minute trace of these bodies remains attached to the finished product. When, however, the whole of the substance produced is to be used as food, including all the chemical reagents which may have been added, the matter assumes an entirely different aspect. The more common materials which are used for the chemical clarification of sugar juices are lime, salicylic acid, phosphoric acid, and salts of tin. Of these, lime alone can be considered harmless, and even lime in large quantities may be decidedly injurious to health. For this reason it is believed best to rely exclusively upon heat and mechanical methods in removing coagulated matter in order to secure the proper clarification. This method of clarification has therefore been persistently followed, and with increased success, as will be set forth in detail in this report.

The results have been highly satisfactory, and it can now be said, upon actual experimental data, that a table sirup can be made from the juice of sugar cane having an attractive light color and being practically free from suspended matter. In other words, the products which our experimental work has secured are composed simply of the concentrated juice of the sugar cane, from which have been removed all of the substances coagulated by heat during all the processes of concentration. Such a product can be offered to the public with absolute certainty of its wholesomeness and freedom from all injurious substances.

The third manufacturing problem which was set for solution was to make a product which would escape fermentation, especially during the hot summer months. It was also determined, if possible, to secure the solution of this problem without the use of any kind of antiseptic. The objections to the use of antiseptics are the same as those which obtain in the case of chemicals used for the clarification of sirup, namely, the possible injury to health. It would be very easy to treat a table sirup during the process of manufacture, or afterwards, with a chemical antiseptic which would effectually prevent its fermentation when exposed to the air or to a high temperature; but this would necessitate the use of substances to which serious objection could be made on the score of injury to health.

The problem of avoiding the use of such substances is a very simple one, and rests upon the very well-known fact that a body which has been sterilized by heat and is, in that condition, placed in sterilized packages and so sealed as to prevent the entrance of germs of fermentation, will keep indefinitely without fermentative action. This fact has long been made use of in the preparation of table sirup in small packages, such as tin cans or glass jars or bottles which are properly sterilized and sealed, and which as long as they remain in this condition never show the phenomenon of fermentation. Our experimental work was, therefore, directed to showing that large packages, such as barrels, if treated in the same way, could be kept free from fermentation indefinitely. To this end the sirup, still hot from the evaporator, was placed in a barrel previously completely sterilized by live steam or otherwise, and fully stoppered with a sterilized cork. Two barrels of sirup prepared in this way have now passed through two summers in the storehouse of the Bureau of Chemistry at Washington without developing any traces of fermentative action. It is evident, therefore, that the great difficulty which the makers and the dealers have had heretofore, arising from the fermentation in the barrels, can be wholly avoided by following the plan of packing outlined above.

The fourth problem which was set for solution related to the introduction of certain economies in the processes of manufacture. These economies were partially secured by the increased extraction which has already been mentioned. The bagasse—that is, the residue of the cane as it leaves the mill—becomes a source of trouble and expense in the ordinary methods of manufacturing sirup in a small way. The services of a man and team are necessary to remove it, and thus the cost of manufacture is increased. Again, following the method employed in large sugar factories, experiments were tried to see whether, on the smaller scale of table-sirup manufacture, the bagasse from the mills could be economically used as a fuel. In the first year's work a boiler was constructed which it was proposed to use for burning both bagasse and wood. This experiment was not attended with very much success. In the second year, therefore, it was decided to erect a boiler especially for the burning of the bagasse. The results of the second year's work were very encouraging, showing that the bagasse could furnish a large part and in some instances all of the fuel necessary not only to drive the mill and press the cane, but also to evaporate the juices to the condition of sirup. In order that the burning of the bagasse may be attended by the most economical results, it is necessary that the factory should run for the full twenty-four hours each day. An intermission over night which allows the boilers to cool necessitates the use of an additional amount of fuel the next morning. The experimental data show that with a continuous run, even in the small mills at the disposal of the factory, the bagasse furnished practically all the fuel necessary for the complete operation of the factory.

It is true that the bagasse can be used for other purposes, i. e., it may be returned to the field as a fertilizer, or be used in the manufacture of paper. In the small quantities in which it is produced in sirup making, however, its utilization in the manufacture of paper pulp is impracticable. The quantity of the fertilizing material which the bagasse contains is very small, and hence its return to the soil adds very little of the essential plant foods, namely, potash, phosphoric acid, and nitrogen. The fibrous nature of the bagasse renders its decay in the soil exceedingly slow, and hence it is not a very satisfactory material for supplying humus. For these reasons it appears clear that the most economical use of the bagasse is for fuel.

CHEMICAL STUDIES.

The chemical studies connected with the investigation are of distinct scientific and economic importance. During the whole course of the experiment the remarkable richness of these sugar canes in crystallizable sugar was shown. It was naturally expected that, by reason of the higher northern latitude and shorter growing season, the canes would be less mature than those grown in Louisiana, but the chemical data seem to show that the contrary of this supposition is true. The canes grown in Georgia present a greater degree of maturity than those grown on the banks of the Mississippi, or in other parts of Louisiana. This fact is doubtless due to the character of the soil, which, being very deficient in plant food, causes a more rapid ripening of the cane. It is evident that a plant which has great stores of food at its disposal will tend to grow for a longer time before reaching its maturity than one growing where the plant foods are deficient.

The data obtained from the chemical control of the factory are also highly interesting. It has been shown that where no alkaline substance is employed in clarification, thus preserving the total acidity of the natural juice, a considerable degree of inversion of the crystallizable sugar occurs during the concentration of the sirup. This natural inversion tends to diminish the crystallizing power of the finished sirup, and thus to avoid one of the principal commercial difficulties connected with the disposal of the product.

By reason of the introduction of complete methods of sterilization of the barrels and other containers it was found possible to preserve the sirup without so great a degree of condensation. Thus it was possible to retain in the sirup as much as 25 per cent of water, giving a product more suitable for winter use and less likely to deposit crystals of sugar. Further, it was shown that a sirup made without the addition of any chemical, depending solely upon heat and mechanical processes for purification, has a finer flavor and is presumably more wholesome than sirups in which the clarification has been accomplished by lime, sulphur, or other chemicals. The complete control of the manufacturing operations disclosed also the character and extent of losses in manufacture and suggested the proper remedies therefor.

Another problem which was investigated was the desirability of establishing distinct grades of sirup for the market and for measuring the color of each of these grades. Unfortunately, perhaps, for the table-sirup industry it is quite customary for sirups for table use to be sold solely on one quality, namely, color; the lighter the color, as a rule, the higher the price paid. When the public taste is educated up to the point of knowing that a certain degree of color is necessary in a genuine sirup, the demand for an exceptionally light sirup will probably be very much diminished. Nevertheless, the delicate red or amber-red tint which a well-made sirup possesses is one which attracts and commands attention. The true measure of the value of a sirup, of course, is not alone its color but its palatability, and more and more this element, so important in sirups, will be considered in determining their market price. Meanwhile it was deemed advisable to establish some standard of color whereby the different grades of sirup could be sold. It is evident that these standards must be arbitrary and should be of such a character as to be easily reproduced and standardized by some central authority, such, for instance, as the Department of Agriculture.

After numerous experiments it was decided to use glycerin as the body of the standard color and to employ varying amounts of caramel made under standard conditions for imparting the various tints thereto. In this manner a series of standard colors was established ranging from the pure water-white glycerin, which was called No. 1, to the darkest possible red tint which could be imparted to glycerin by caramel, a tint so red that in any quantity it appears black. Such a series of standards has been declared in the Bureau of Chemistry of the Department of Agriculture, and when authority is granted by Congress can be made and supplied under the seal of the Department to manufacturers and dealers throughout the country. It is found that where a sirup is carefully made from the natural juice and without the use of chemicals of any kind the usual ranges in color, as judged by the standards above mentioned, lie between No. 10 and No. 15. The average tint of No. 12 is an excellent one for a table sirup.

It is further evident that the success of the sugar-cane sirup industry lies not alone in improving the character and methods of manufacture of the sirup, but also in obtaining for the product an unrestricted market. To this end it is necessary that all classes of table sirup which are placed upon the market should be correctly labeled so that the purchaser may be able, if he desires, to obtain a genuine sugar-cane sirup in the market. In other words, any wholesome saccharine material may be properly used in the manufacture of a tab'e sirup, provided no deception or fraud be practiced. Glucose, as is well known, forms a body of a saccharine character which is extremely useful in the manufacture of sirup for table use. A mixture of glucose with sugar-cane sirup makes a very attractive and palatable article. All such mixtures, however, should be sold under their true names, and thus each one would secure an open and fair competition in the markets of the country. It is believed that if such a regulation were rigorously applied in all the States and in interstate commerce the market for sugar-cane sirup would be rapidly enlarged, and thus the industry would be placed upon a firmer and more profitable basis.

CULTURAL DATA.

AGRICULTURAL EXPERIMENTS AT CAIRO, GA., 1903 AND 1904.

For the conduct of the experimental field work at Cairo, Ga., under the supervision of Mr. W. B. Roddenbery, in 1903, the general directions were given in writing. In addition to the written directions a design for the arrangement of the experimental plots was also furnished (see page 18). This scheme of mapping the plots and applying the fertilizer was followed, with very little variation, in the actual work. One or two slight changes were made by Mr. Roddenbery as the result of his practical experience, which, however, do not affect the general scheme submitted.

The composition of the fertilizers which were used is shown in the following table:

TABLE I.—*Composition of fertilizers used at Cairo, Ga., in plat experiments, 1903.*

Serial No.	Description.	Phosphoric acid.			Potash (K_2O).	Nitrogen.
		Total.	Insoluble.	Available.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1613	Nitrate of soda	....	....	....	....	14.99
1614	Kainit	....	....	....	12.05	....
1615	Muriate of potash	....	....	....	51.50	....
1616	Cotton-seed meal	2.15	....	....	3.30	6.04
1617	Cotton seed	1.11	....	....	.81	2.77
1618	Acid phosphate (16 per cent)	15.60	1.09	14.51	....	....
1619	Normal formula complete	8.69	.60	8.09	5.37	2.96
1628	Peruvian guano	21.70	....	....	4.40	4.00

PLAN OF THE EXPERIMENTS FOR 1903.

According to the following scheme for the experimental plats at Cairo, an area 600 feet long and 136 feet wide, or two parallel adjacent areas each 300 feet long and 136 feet wide may be used, as convenient. Each plat is 20 feet by 136 feet and contains exactly one-twentieth of an acre. The rows of cane are to be 4 feet apart with one unfertilized row between the plats. There are also unfertilized plats between the series, viz, 1, 5, 9, 13, 17, 23, and 30.

Diagram showing plan of plats and fertilization for experiments in growing sugar cane at Cairo, Ga., 1903.

136 feet.

1	No fertilizer.
2	800 pounds normal formula: 1 application.
3	1,200 pounds normal formula: 1 application.
4	2,000 pounds normal formula; 1 application.
5	No fertilizer.
6	800 pounds normal formula; 2 applications.
7	1,200 pounds normal formula; 2 applications.
8	2,000 pounds normal formula; 2 applications.
9	No fertilizer.
10	800 pounds normal formula: 3 applications.
11	1,200 pounds normal formula; 3 applications.
12	2,000 pounds normal formula; 3 applications.
13	No fertilizer.
14	720 pounds acid phosphate; 2 applications.
15	120 pounds muriate of potash; 2 applications.
16	240 pounds nitrate of soda; 2 applications.
17	No fertilizer.
18	720 pounds acid phosphate 240 pounds nitrate of soda } 2 applications.
19	720 pounds acid phosphate 120 pounds muriate of potash } 2 applications.
20	120 pounds muriate of potash 120 pounds nitrate of soda } 2 applications.
21	720 pounds acid phosphate 480 pounds kainit } 2 applications.
22	720 pounds acid phosphate 480 pounds cotton-seed meal } 2 applications.
23	No fertilizer.
24	720 pounds acid phosphate; 2 applications.
25	480 pounds kainit; 2 applications.
26	480 pounds cotton-seed meal; 2 applications.
27	800 pounds normal formula; 2 applications.
28	1,200 pounds normal formula; 2 applications.
29	2,000 pounds normal formula; 2 applications.
30	No fertilizer.

600 feet.

Note.—If more convenient, this plan may be modified by laying off two experimental fields side by side, each 136 feet wide and 300 feet long.

The quantity of fertilizer per acre to be applied to each plat is indicated in the foregoing diagram. A carefully conducted experiment on a field containing a little over an acre and a half will be quite as useful as to experiment on 100 acres, as has been suggested. The fertilizer to be applied to plats 7 and 11 in the scheme gave the best results in the experimental work of 1902.

The normal formula for making up a ton of the mixed fertilizer is as follows:

	Pounds.
Acid phosphate (16 per cent available)	1,200
Cotton-seed meal	400
Nitrate of soda	200
Muriate of potash	200
Total	2,000

Instead of muriate of potash an equal amount of sulphate of potash may be used if more convenient. The best way is to purchase the several ingredients and mix them. The following quantities of these ingredients will be sufficient for our purpose, viz:

	Pounds.
Acid phosphate	2,400
Cotton-seed meal	800
Nitrate of soda	400
Muriate of potash	400

For the normal formula it will be sufficient to mix half a ton. The remainder of the ingredients can be used for making the special fertilizers. The only other mixtures used are those to be applied to plats 18, 19, 20, 21, and 22. The actual amounts to be mixed for these plats are as follows:

Plat 18: Acid phosphate, 36 pounds, and sodium nitrate, 12 pounds.
Plat 19: Acid phosphate, 36 pounds, and muriate of potash, 6 pounds.
Plat 20: Muriate of potash, 6 pounds, and nitrate of soda, 6 pounds.
Plat 21: Acid phosphate, 36 pounds, and kainit, 24 pounds.
Plat 22: Acid phosphate, 36 pounds, and cotton-seed meal, 24 pounds.

The amounts written in for the various plats on the plan are the total amounts for one acre, and the number of pounds to be actually applied to the plat is in each case one-twentieth of the amount given. For instance, to plat No. 2 only 40 pounds are to be applied; to plat No. 3, 60 pounds, and to plat No. 4, 100 pounds, etc.

After mixing, the fertilizers must be kept in a dry place until used. When only one application of the fertilizer is to be made, it should be made at the time of planting; when two are made, one half of the fertilizer should be applied at the time of planting, and the other half early in June. When three applications are made, one-third should be applied at the time of planting, one-third early in June, and one-third not later than July 15.

REPORT OF EXPERIMENTS WITH PLANT CANE, 1903.

By W. B. Roddenbery, *Cairo, Ga.*

The plat experiments to determine the effect of fertilizers on the yield and quality of sugar cane were conducted on two fields, A and B. There are 42 plats (12 more than contemplated in the original plan) in each field, each plat being 136 feet long by 20 feet wide, with 5 rows to each plat, except that No. 34 has 6 rows and No. 35 has 4 rows. Four rows in each plat are used for the fertilizer experiment, and 1 row is left unfertilized, to prevent the cane from feeding on fertilizers in adjoining plats. Each plat contains one-twentieth of an acre, making 2.1 acres in each field.

Fields A and B were treated alike in every way, the experiments being duplicates except for the difference in the land. Field A is very old land, poor and sandy. It had been planted in corn and pindars (peanuts) for several years, with an application of about 200 pounds of guano [a] per acre each year. It was turned over in January with a two-horse plow 7 to 8 inches deep, and harrowed with a disk harrow March 20, just before planting.

Field B is very old sandy land of the same grade as Field A, and very poor. It was planted in oats, followed by cowpeas for two years preceding the cane experiment. The crop of peas in 1902 was very heavy, and the vines were cut for hay. About 12 two-horse wagon loads of cane bagasse per acre were spread broadcast on this field in January, and turned under to a depth of 8 inches with a two-horse plow January 7. The bagasse was 1 year old when put out, and was, therefore, partially rotted. The land was harrowed with a disk harrow on March 21, just before planting.

Field A was planted on March 26, and Field B on March 23, 1903. The rows on each field were laid off, opened with a one-horse plow with an 8-inch round shovel, and the fertilizer was applied carefully by hand in this furrow, the cane being planted in the same furrow on top of the fertilizer, and covered with two 4-inch bull-tongue furrows. Stubble cane with very short joints, cut in pieces about 1 foot long, was planted with about 3 inches between the pieces. The variety of cane used for seed was red and purple.

Fertilization of the Plats.

The scheme of fertilizing employed is as follows, on both fields:

Plat 1: No fertilizer.
Plat 2: 800 pounds normal formula; 1 application.
Plat 3: 1,200 pounds normal formula; 1 application.
Plat 4: 2,000 pounds normal formula; 1 application.
Plat 5: No fertilizer.
Plat 6: 800 pounds normal formula; 2 applications.
Plat 7: 1,200 pounds normal formula; 2 applications.
Plat 8: 2,000 pounds normal formula; 2 applications.
Plat 9: No fertilizer.
Plat 10: 800 pounds normal formula; 3 applications.
Plat 11: 1,200 pounds normal formula; 3 applications.
Plat 12: 2,000 pounds normal formula; 3 applications.
Plat 13: No fertilizer.
Plat 14: 720 pounds acid phosphate alone.
Plat 15: 120 pounds muriate of potash alone.
Plat 16: 240 pounds nitrate soda alone.
Plat 17: No fertilizer.

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[a] An expression in common use in this part of the South for any complete commercial fertilizer.

Plat 18: No potash; normal ration[a] of ammonia and phosphate; ammonia from nitrate of soda.

Plat 19: No ammonia; normal ration of phosphate and potash; potash from muriate of potash.

Plat 20: No phosphate; normal ration of ammonia and potash.

Plat 21: No ammonia; normal ration of phosphate and potash; potash from kainit.

Plat 22: No potash; normal ration of ammonia and phosphate; ammonia from cotton-seed meal.

Plat 23: No fertilizer.

Plat 24: 720 pounds acid phosphate alone.

Plat 25: 480 pounds kainit alone.

Plat 26: 480 pounds cotton-seed meal alone.

Plat 27: 800 pounds normal formula; 2 applications.

Plat 28: 1,200 pounds normal formula; 2 applications.

Plat 29: 2,000 pounds normal formula; 2 applications.

Plat 30: No fertilizer.

Plat 31: 800 pounds normal formula; broadcast.

Plat 32: 1,200 pounds normal formula; broadcast.

Plat 33: 2,000 pounds normal formula; broadcast.

Plat 34: 3½-foot rows, 6 rows to plat; 1,200 pounds normal formula; 2 applications.

Plat 35: 5-foot rows, 4 rows to plat; 1,200 pounds normal formula; 2 applications.

Plat 36: Ribbon cane; 1,200 pounds normal formula; 2 applications.

Plat 37: 24 bushels cotton seed per acre as the ammoniate, with normal ration of potash and phosphate.

Plat 38: 57 bushels cotton seed per acre as the ammoniate, with normal ration of potash and phosphate.

Plat 39: Double phosphate[b] with normal ration of ammonia and potash.

Plat 40: Double potash[b] with normal ration of ammonia and phosphate.

Plat 41: Double ammonia[b] with normal ration of potash and phosphate.

Plat 42: No fertilizer.

It will be noted that the experiments on plats 1 to 30 were carried out exactly as indicated in the original plan (p. 18). On the last 12 plats experiments were made to test several features of fertilization not included in the original plan.

RESULTS OF THE EXPERIMENTS.

The yield of cane per acre upon each of the plats on fields A and B and the composition of the expressed juices therefrom are shown in the following tables. The first table contains the data for the comparison of 5 plats in block, and the second the data for the uncompared plats.

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[a] A "normal ration" is the amount which would be contained in 1,200 pounds of normal formula fertilizer per acre.

[b] Double the normal ration.

TABLE II.—*Results of fertilizer experiment with sugar cane, Cairo, Ga., 1903.*

Plat No.	Fertilizer.	Yield per acre.		Sucrose.		Reducing sugar.		Purity.		Stand on scale of 100.			
										April 28.		June 6.	
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
	PLATS IN GROUPS.	*Tons.*	*Tons.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*						
1	No fertilizer	4.75	2.30	8.4	7.0	1.45	1.34	70.9	71.6	70	20	90	30
5	.....do	7.15	4.35	8.4	9.6	1.92	1.82	63.6	71.0	15	20	35	40
9	.....do	5.25	3.05	9.5	7.0	1.90	1.34	72.3	71.6	25	20	60	40
13	.....do	2.90	2.95	7.9	7.9	1.70	1.58	63.9	67.9	40	30	60	50
17	.....do	11.35	3.15	10.3	9.5	1.92	1.40	69.6	69.8	20	30	70	55
23	.....do	7.75	2.25	10.6	6.2	1.42	1.47	76.6	75.5	20	20	60	45
30	.....do	1.30	3.15	7.9	7.0	1.70	1.34	61.2	71.6	10	50	40	70
42	.....do	3.25	2.85	7.9	7.0	1.70	1.34	61.2	71.6	60	20	80	50
	Average	5.46	3.01	8.9	7.6	1.71	1.45	67.4	71.3	....	....	....	....
[a]21	No fertilizer	9.12	12.00	15.72	14.17	.44	1.21	92.3	86.2	50	40	75	50
2	800 pounds normal formula; 1 application	11.15	14.27	10.60	11.00	1.41	1.57	77.7	74.7	15	15	35	40
6	800 pounds normal formula; 2 applications	13.45	10.55	9.20	10.00	2.00	1.58	67.6	75.0	20	40	75	60
10	800 pounds normal formula; 3 applications	10.05	9.50	10.90	9.10	1.79	1.48	79.9	75.9	70	30	80	70
27	800 pounds normal formula; 2 applications	17.25	10.65	10.20	10.05	1.69	1.28	73.4	76.7	15	40	60	70
31	800 pounds normal formula; broadcast	7.20	7.95	9.80	10.60	1.58	1.30	75.7	76.6	20	40	50	65
	Average	11.82	10.58	10.14	10.15	1.69	1.44	74.8	75.8	....	....	....	....
3	1,200 pounds normal formula; 1 application	11.95	14.32	10.10	....	1.53	....	73.0	....	10	20	30	35
7	1,200 pounds normal formula; 2 applications	13.30	16.15	9.80	10.70	1.92	1.58	68.8	73.2	20	40	65	70
11	1,200 pounds normal formula; 3 applications	11.55	11.50	9.16	10.00	2.06	1.58	68.3	72.8	20	25	60	75
28	1,200 pounds normal formula; 2 applications	13.50	13.60	10.20	10.60	1.66	1.48	72.2	73.5	10	40	40	65
32	1,200 pounds normal formula; broadcast	12.10	9.05	10.60	10.80	1.40	1.69	76.6	77.5	70	85	35	60
	Average	12.48	12.92	9.97	10.52	1.71	1.58	71.8	74.3	....	....	....	....
4	2,000 pounds normal formula; 1 application	11.95	16.00	11.10	9.20	1.39	1.74	76.4	67.6	10	15	20	30
8	2,000 pounds normal formula; 2 applications	15.45	16.35	9.60	9.30	1.98	1.99	69.5	67.3	15	20	60	50
12	2,000 pounds normal formula; 3 applications	15.35	15.15	10.60	10.20	1.75	1.68	71.6	72.2	10	30	50	70
29	2,000 pounds normal formula; 2 applications	15.60	15.35	10.50	10.50	1.63	1.60	75.9	75.4	25	30	60	65
33	2,000 pounds normal formula; broadcast	15.30	13.40	10.80	10.80	1.52	1.32	76.4	77.5	75	85	30	60
	Average	14.73	15.25	10.52	10.00	1.65	1.66	73.9	72.0	....	....	....	....

	MISCELLANEOUS PLATS.												
14	Acid phosphate alone, 720 pounds	7.10	4.65	....	9.0	....	1.40	....	75.3	20	20	50	45
24	....do	12.50	3.45	11.1	7.6	1.37	1.21	79.1	71.3	25	35	65	60
15	Potash alone, 120 pounds muriate	9.15	7.75	10.6	10.7	1.78	1.21	71.5	77.4	10	35	35	60
25	Potash alone, 480 pounds kainit	9.35	7.70	9.6	9.2	1.77	1.56	72.6	69.6	10	20	25	40
26	Ammonia alone, 480 pounds cotton-seed meal	12.65	7.10	10.1	8.5	1.56	1.38	76.9	70.0	20	30	65	60
18	No potash; normal phosphorus and ammonia (from nitrate of soda)	12.70	6.50	12.2	9.6	1.43	1.36	77.6	70.5	15	40	50	60
22	No potash; normal phosphorus and ammonia (from cotton-seed meal)	8.50	5.75	10.7	8.2	1.50	1.49	73.7	69.8	15	35	40	65
19	No ammonia; normal phosphorus and potash (from muriate)	14.35	7.75	12.3	10.4	1.34	1.50	75.9	74.1	15	30	70	55
21	No ammonia; normal phosphorus and potash (from kainit)	13.15	10.10	10.4	11.5	1.28	1.18	66.7	80.2	10	25	35	60
20	No phosphorus; normal ammonia (from nitrate of soda), and potash (from muriate)	9.85	8.20	11.7	10.6	1.67	1.32	77.9	77.7	10	25	60	55
39	Double phosphate; normal potash and ammonia	12.85	15.45	10.5	11.2	1.45	1.24	75.4	81.5	10	20	40	40
40	Double potash; normal ammonia and phosphate	11.05	14.20	10.4	10.6	1.86	1.38	74.7	78.3	10	15	40	30
41	Double ammonia; normal potash and phosphate	12.75	13.15	10.7	9.9	1.73	1.93	73.7	71.6	20	25	60	40
34	3½-foot rows; 1,200 pounds normal formula; 2 applications	12.75	11.00	11.4	10.6	1.24	1.40	81.0	78.3	70	30	85	70
35	5-foot rows; 1,200 pounds normal formula; 2 applications	10.60	11.40	10.8	11.1	1.60	1.58	74.4	73.9	15	30	60	70
36	Ribbon cane; 1,200 pounds normal formula; 2 applications	11.20	11.05	10.6	11.1	1.58	1.39	76.6	76.4	15	20	65	30
37	24 bushels cotton seed; normal potash and phosphate; 2 applications	10.55	13.20	10.84	10.5	1.48	1.37	76.4	75.9	15	50	70	75
38	57 bushels cotton seed; normal potash and phosphate; 2 applications	13.90	16.35	11.0	10.8	1.43	1.47	76.2	77.0	20	50	70	80
	Average	11.39	9.71	10.88	10.06	1.53	1.41	75.3	74.9	....	....	....	....

[a] An unfertilized plat from the 1902 experiments inserted here for comparison.

All amounts of fertilizer refer to quantities per acre, only one-twentieth of these amounts being used on the plats. All the plats had two applications of fertilizers unless otherwise mentioned, the second application being made on both sides of the row on June 3. The third application was made on July 15.

The season of 1903 was very unfavorable for sugar cane at Cairo. During April it was too dry for the cane to germinate well; therefore the stand was very poor. During May it was very cool, which prevented the cane from getting a rapid and vigorous start. From the middle of August until September 13 we had a severe drought and the cane suffered badly. This was followed by a heavy rain and wind storm on September 13, which prostrated the cane badly, and the favorable effects of the rain, which was much needed, were counteracted by two or three weeks of unusually cool weather immediately after the storm, which prevented the expected fall growth.

The following table shows the stand of cane on the different plats, as observed on April 28 and June 6; also the yields of sugar cane harvested in the fall:

TABLE III.—*Stand of cane on two dates in the spring, and yield in the fall, Cairo, Ga., 1903.*

Plat No.	Stand[a] of cane.				Yield of cane per acre.	
	April 28.		June 6.			
	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
					Tons.	*Tons.*
1	70	20	90	30	4.75	2.30
2	15	15	35	40	11.15	14.27
3	10	20	35	35	11.95	14.32
4	10	15	20	30	11.95	16.00
5	15	20	35	40	7.15	4.35
6	20	40	75	60	13.45	10.55
7	20	40	65	70	13.30	16.15
8	15	20	60	50	15.45	16.35
9	25	20	60	40	5.25	3.05
10	70	30	80	70	10.05	9.50
11	20	25	60	75	11.55	11.50
12	10	30	50	70	15.35	15.15
13	40	30	60	50	2.90	2.95
14	20	20	50	45	7.10	4.65
15	10	35	35	60	9.15	7.75
16	10	25	40	55	13.75	4.50
17	20	30	70	55	11.35	3.15
18	15	40	50	60	12.70	6.50
19	15	30	70	55	14.35	7.75
20	10	25	60	55	9.85	8.20
21	10	25	35	60	13.15	10.10
22	15	35	40	65	8.50	5.75
23	20	20	60	45	7.75	2.25
24	25	35	65	60	12.50	3.45
25	10	20	25	40	9.35	7.70
26	20	30	65	60	12.65	7.10
27	15	40	60	70	17.25	10.65
28	10	40	40	65	13.50	13.60
29	25	30	60	65	15.60	15.35
30	40	50	60	70	1.30	3.15
31	20	40	50	65	7.20	7.95
32	70	35	85	60	12.10	9.05
33	75	30	85	60	15.30	13.40
34	70	30	85	70	12.75	11.00
35	15	30	60	70	10.60	11.40
36	15	20	65	30	11.20	11.05
37	15	50	70	75	10.55	13.20
38	20	50	70	80	13.90	16.35
39	10	20	40	40	12.85	15.45
40	10	15	40	30	11.05	14.20
41	20	25	60	40	12.75	13.15
42	60	20	80	50	3.25	2.15

[a] On basis of 100 as perfect.

The cane from the experimental plats was harvested and ground on December 14, 15, and 16, after having been frozen repeatedly during November and December. The juice was slightly acid to the taste, and a sample from each plat was sent to the Department for analysis. (See Table II.)

DISCUSSION OF RESULTS.

The yields on the normal formula plats show some very erratic results, which make it difficult to draw conclusions of practical value; but grouping all the 800-pound normal-formula plats and comparing them with the 1,200-pound and 2,000-pound plats, it is seen that the general averages show very slightly increased profits from the increased quantities of fertilizer.

TABLE IV.—*Increase of yield compared with cost of fertilizer, Cairo, Ga., season of 1903.*

Number of plats.	Fertilizer per acre.	Cost of fertilizer per acre.	Yield per acre.
	Pounds.		*Tons.*
10	800	$9.00	11.20
10	1,200	13.50	12.70
10	2,000	22.50	14.99

Thus we see that the 1,200-pound plats show a gain of 1.5 tons per acre over the 800-pound plats. The 2,000-pound plats show a gain of 2.29 tons per acre over the 1,200-pound plats, and a gain of 3.79 tons per acre over the 800-pound plats. At a valuation of $4 per ton for this cane, and deducting the extra cost of the increased amount of the fertilizers, the net profits are as follows:

The average net profit per acre where 1,200 pounds of fertilizer was used exceeded that where 800 pounds was used by $1.50, and where 2,000 pounds was used the excess was $1.66, while the profit with 2,000 pounds exceeded that with 1,200 pounds by only 16 cents.

Therefore we must conclude that it is useless to apply as much as 2,000 pounds of this formula in seasons like 1903; 1,200 pounds per acre would be sufficient.

As to the best manner of applying the normal-formula fertilizer, the results point to two applications as being the most profitable, the yields being as follows:

Methods of applying fertilizers and resulting yields of cane.

	Tons of cane per acre.
One application	13.27
Two applications	14.27
Three applications	12.25
Broadcast	10.83

These results bear out the conclusions from the 1902 experiments. The analyses of the juices show no appreciable differences.

The eight plats on which no fertilizers were used show an average yield of 5.46 tons of cane per acre on field A and 3.01 tons per acre on field B. One plat, No. 30, in field A (no fertilizer) gave only 1.3 tons per acre. These yields prove conclusively that sugar cane can not be grown profitably on this kind of soil without fertilizers, as the gross proceeds of the cane produced would not pay the cost of the seed, cultivation, and harvesting, to say nothing of the land rent.

The cane grown on the unfertilized plats averaged 8.25 per cent of sucrose against an average of 10.2 per cent on the plats fertilized with the normal formula, while the purity averaged 69.4 on the unfertilized plats against 72.9 on the fertilized plats. This shows that low sugar content and low purity accompany low tonnage of cane as a result of no fertilization.

The effect of different seasons is very clearly shown by comparing the yield of these unfertilized plats with the yield of the unfertilized plats of the 1902 experiment. The soil of field A, 1902, is practically the same as that of fields A and B, 1903, but we find that in 1902 the yield was 9.12 tons per acre and the sucrose 15.72 per cent, or about double the tonnage and sugar content of 1903.

The average yield of these 16 unfertilized plats and of the 30 plats fertilized with normal formula—800 pounds to 2,000 pounds per acre—are 4.23 tons per acre on unfertilized and 12.96 tons on fertilized plats, showing a gain of 8.73 tons per acre by use of fertilizers, and a profit of $20.68 per acre above the cost of the fertilizers.

The results on the plats where phosphate, potash, and ammonia were used in varying quantities, and different combinations in order to determine the relative values of the three ingredients are so conflicting that it is impossible to draw any very useful lessons therefrom. However, a few side lights can be thrown on the subject by analyzing closely these results.

Consider, first, the ammonia plats, Nos. 16, 26, 19, 21, and 41. On field A, plats 16 and 26, where ammonia alone was applied, gave an average yield of 13.2 tons per acre. Plats 19 and 21, with no ammonia but a normal amount of phosphate and potash, gave a yield of 13.75 tons. On plat 41, where the ammonia was doubled, and the normal amount of phosphate and potash was applied, we have a yield of 12.75 tons, less than from either of the other two plats. Plat 41 should also be compared with plats 7 and 28, which received 1,200 pounds of normal formula fertilizer in two applications, the average yield being 13.4 tons. It is clear that doubling the amount of ammonia on plat 41 was of no benefit whatever, as the yield from that plat was less than from either of the others. Also compare these ammonia plats with plats 6 and 27, to which 800 pounds of the normal formula was applied in two applications, the average yield being 15.35 tons on field A, a considerably larger yield than on any of the plats mentioned above, all of which shows that the use of a properly balanced fertilizer in comparatively small quantities gives the best results. In other words, 800 pounds of normal formula contained a sufficient amount of ammonia for an acre of this field.

But a study of the same plats on field B shows different results: No ammonia gives 8.92 tons; ammonia alone, 5.8 tons; double ammonia, 13.15 tons; 1,200 pounds of normal formula gives 14.87 tons, and 800 pounds of normal formula 10.6 tons. This shows that on field B a larger amount of ammonia was needed than on field A, and that 800 pounds of normal formula per acre was too small a quantity to produce best results; still the proportion of ammonia in the normal formula was approximately right. (See results from use of 1,200 pounds of normal formula.)

The potash and phosphate plats, studied in the same manner, show that the normal formula contained a sufficient amount of these two ingredients, as doubling the quantity of each did not produce any increased yield over 1,200 pounds of the normal formula in either field. Where either the potash or phosphate was used alone the yield was decreased to such an extent as to show conclusively that each is needed.

In studying these plats, it may be noted that a low percentage of sugar is nearly always coupled with a small yield in tons of cane, and a larger crop has a higher percentage of sugar.

In plats 34 and 35 we have a comparison of wide and narrow rows. Field A gave a gain of 2.15 tons per acre in 3.5 foot rows over 5-foot rows, whereas field B yielded 11.4 tons on 5-foot rows against 11 tons on 3.5-foot rows. No practical conclusions can be drawn from these results.

Plats 37 and 38, on which cotton seed was used as an ammoniate instead of cottonseed meal or nitrate of soda, gave results which confirm the conclusions drawn from the 1902 experiment with cotton seed, viz, that cotton seed is too expensive to use as a fertilizer at the present prices of seed and other fertilizing ingredients. Plat 37 with $13.20 worth of fertilizer gave a yield of 10.55 tons of cane on field B and 13.20 tons on field A as against an average of 13.40 and 14.87 tons on plats 7 and 28 with

1,200 pounds of normal formula per acre at approximately the same cost as the cotton-seed plat. The other cotton-seed plat, No. 38, with $20.62 worth of fertilizer gave 13.90 and 16.35 tons per acre, against 13.40 and 14.87 tons on plats 7 and 28 with $13.50 worth of fertilizer. The largest yield, 16.35 tons from plat 38, shows a net loss of $1.20 by the use of cotton seed instead of meal.

The very short season for growing sugar cane in 1903 was mainly responsible for the small yields, and for the same reason the fertilizers did not have time to exert their full influence. For these reasons the experiments of 1903 are not so valuable as they would have been under more favorable circumstances.

COMMENT ON RESULTS AT CAIRO, 1903.

To Mr. Roddenbery's observations the following comment may be added:

From a study of the data it is seen that the average yield of the plats where no fertilizer was employed was 5.46 tons on field A and 3.01 tons on field B. The importance of duplicating the plats, especially when they are so small in area, is brought out in a prominent manner by the data. For instance, plat No. 30 on field A produced only 1.3 tons of cane per acre, while plat 17 on the same field produced 11.35 tons per acre. These differences in yield of course are due chiefly to differences in the stand of the cane.

In the five plats to which 800 pounds per acre of the "normal formula" fertilizer were applied the yield was considerably increased on both fields, the average on field A being 11.82 tons per acre and on field B 10.58 tons per acre.

In the five plats to which 1,200 pounds of the normal formula fertilizer were applied per acre the average yield on field A was 12.48 tons per acre and on field B 12.92 tons per acre. It is seen that the application of this quantity of fertilizer practically eliminated the differences in the natural fertility of the two fields. In the plats to which 2,000 pounds of the same fertilizer were applied per acre the average yield on field A was 14.73 and on field B 15.25. In this case the somewhat surprising result is shown of the poorer field yielding more per acre than the richer.

In some cases it is seen that the application of the fertilizer at different times increases the yield, while in other cases the yield is best where the whole of the fertilizer is applied at once. The data are not sufficiently definite to decide whether or not it is advisable to apply the fertilizer all at once or by installments. In general the latter seems preferable. In those plats where no extensive comparison of the same quantity of fertilizer was made, the data for which appear in the latter part of Table II, it is noticed that the largest yield in field A is in plat 19, where no nitrogen, but the normal amount of potash, and phosphoric acid was added, the potash being derived from the muriate. The yield in this case was 14.35 tons per acre.

The largest yield in field B was in plat 38 which received an application of 57 bushels of cotton seed and the normal amount of potash and phosphoric acid, in two applications. The yield in this case reached 16.35 tons per acre. When these yields are compared with those of the previous year,[a] a very marked difference is seen. The data show that the yield in sugar cane in 1902 was not only very much greater per acre, but that it contained a very much larger percentage of sugar. The great decrease in yield in 1903 as well as the decrease in the quality of the cane must be ascribed solely to seasonal influences. The character of the soil on which the 1903 crop was grown and the kind and quantity of fertilizer used were practically the same as those of the previous year. By referring to the report for 1902[a] the great richness of the cane in sugar is at once noticed; indeed, it was of a quality which could be very successfully used in the manufacture of sugar, the average percentage of sucrose in the canes grown on field A being 15.78 and on field B 14.27. These are quite in contrast with the figures for the two fields for 1903, which are 10.13 and 9.67, respectively.

REPORT OF EXPERIMENT WITH STUBBLE CANE, 1903.

By W. B. RODDENBERY.

The results from the experiment with stubble cane are very interesting and instructive. The conditions of this experiment were as follows:

In 1902 a fertilizer experiment was conducted on fields A and B, the results of which are recorded in the report for that year.[a]

TREATMENT AND YIELD.

In the fall the cane from these two fields was cut and made into sirup. The stubble remaining in the ground through the winter was treated in the usual manner, viz, "barred off" in February of 1903 and harrowed across the rows. Then in April an application of 400 pounds per acre of normal formula fertilizer was applied around the roots, and in June another application of 400 pounds was made.

The eyes left on the roots put out a growth, and a crop of rattoon or stubble cane was made during 1903. The cane on field A was dug up in the fall of 1903 and put down in bed for seed for the crop of 1904, hence no data as to yield were obtained; but on field B the cane was harvested as usual and made into sirup. The cane from each plat was weighed and the results are given in the following table:

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[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 75: Sugar-cane culture in the Southeast for the manufacture of table sirup.

TABLE V.—*Fertilization and yield of stubble cane from field B, Cairo, Ga., experiments of 1902 and 1903.*

Plat No.	Fertilizer[a] applied in 1902.	Yield of cane, 1902.	Yield of stubble cane, 1903.
		Tons.	*Tons.*
1	1,200 pounds normal formula; broadcast	26.88	15.60
2	1,200 pounds normal formula; 1 application	27.64	14.70
3	1,200 pounds normal formula; 2 applications	28.72	15.60
4	1,200 pounds normal formula; 3 applications	28.00	16.40
	Average	27.81	15.07
5	2,000 pounds normal formula; broadcast	35.36	15.65
6	2,000 pounds normal formula; 1 application	23.84	18.65
7	2,000 pounds normal formula; 2 applications	39.40	18.90
8	2,000 pounds normal formula; 3 applications	28.88	17.25
	Average	31.87	17.61
9	800 pounds normal formula; 1 application	25.76	16.65
10	800 pounds normal formula; 2 applications	28.32	13.35
	Average	27.04	15.00
11	1,200 pounds low-grade guano	24.08	16.90
12	No potash; normal ammonia and phosphate	19.76	10.50
13	No ammonia; normal phosphate and potash	24.40	15.30
14	No phosphate; normal potash and ammonia	18.80	7.30
15	Double phosphate; normal ammonia and potash	31.50	13.15
16	Double ammonia; normal potash and phosphate	24.50	13.00
17	Double potash; normal ammonia and phosphate	25.60	16.15
18	675 pounds acid phosphate, 525 pounds c. s. meal, 110 pounds muriate of potash	29.00	15.00
19	756 pounds acid phosphate, 221 pounds nitrate of soda, 126 pounds muriate of potash	29.08	13.65
20	24 bushels cotton seed, 720 pounds acid phosphate, 120 pounds muriate of potash	26.32	13.00
21	57 bushels cotton seed, 650 pounds acid phosphate, 97 pounds muriate of potash	31.62	13.20
22	720 pounds acid phosphate, 240 pounds c. s. meal, 120 pounds nitrate of soda, 480 pounds kainit	26.60	13.00
23	720 pounds acid phosphate, 240 pounds c. s. meal, 120 pounds nitrate of soda, 120 pounds muriate of potash	26.60	17.00
24	No fertilizer	12.00	10.25

[a] These fertilizers were applied to the regular crop for 1902. In the spring of 1903, 800 pounds additional normal formula fertilizer were applied around the stubble.

STATEMENT OF RESULTS.

The land on which this cane grew is better land than that devoted to the fertilizer experiment with plant cane in 1903, hence the general yield was greater.

An increased yield by 2½ tons per acre was obtained in 1902 where 2,000 pounds of the normal formula fertilizer were applied, as compared with the yields where 1,200 pounds was used; but the yield was practically the same where 800 pounds were applied as where an application of 1,200 pounds was made.

The most interesting result of this experiment is to be found in the fact that the rattoon crop of 1903 seems to have derived but little, if any, benefit from the 1902 application of ammonia, but large benefit from the potash and phosphate. Plat 13 with no ammonia in 1902, but a normal ration of phosphates and potash, gave a yield of 15.30 tons of stubble cane in 1903 as against 13 tons on plat 16 where the ammonia was doubled in 1902, and 10.25 tons on plat 24, where no fertilizer was applied in 1902. Plat 14, where no phosphate was applied in 1902, gave a yield of only 7.3 tons, although this plat had the normal amounts of potash and ammonia, while plat 15, which also had a normal ration of ammonia and potash, but a double ration of phosphate, yielded 13.15 tons.

Also the result on the two cotton-seed plats, 20 and 21, is of interest. It is generally contended by those who advocate cotton seed as a fertilizer for sugar cane that good results can always be had on the stubble crop from the applications of cotton seed made in former years. On plat 20, where 24 bushels of cotton seed was applied in 1902, the yield of stubble cane is 13 tons, while on plat 21, where 57 bushels of cotton seed was applied, the yield is 13.2 tons, and compared with the yields on other plats these fall behind nearly all of them.

It is fairly safe to conclude that there is little, if any, waste from an excessive application of potash and phosphate on plant cane, as the succeeding stubble crop will get the benefit, but an excessive application of ammonia will be lost, as it has practically all disappeared by the following year.

REPORT ON EXPERIMENTS IN 1904.

By W. B. Roddenbery, *Cairo, Ga.*

These experiments were conducted under my supervision on two fields, A and B. There were 42 plats in field A and 46 in field B, of the same size as those described in the experimental work for 1903.

Description of Plats and Fertilization.

Field A is a good grade of pine land, being what is termed stiff, pimply land, full of small brown pebbles on the surface, and having a stiff clay subsoil. It was planted in oats in the winter of 1902, followed by cowpeas in the summer of 1903, the pea vines being cut for hay. The land has been cultivated since 1860. The ground was broken about 9 inches deep in January with a disk plow and harrowed with disk harrows just ahead of planting. The rows were laid off 4 feet apart with a 10-inch round shovel. The fertilizer was applied by hand, in drills, followed by a small plow to mix soil and fertilizer. Seed cane was cut in lengths of about 18 inches, which were dropped end to end in a single row in the furrow, and covered with two 4-inch scooter furrows. The cane was planted on March 10. The following are the formulas for mixing the fertilizer:

Normal formula.

	Pounds.
Acid phosphate	1,200
Cotton-seed meal—Upland cotton	400
Nitrate of soda	200
Muriate of potash	200

Revised formula.

Acid phosphate	1,200
Cotton-seed meal—Upland cotton	300
Nitrate of soda	100
Muriate of potash	200

This revised formula is being tried on the theory that all the phosphate and potash and about half the nitrogen should be applied at the time of planting, and the other half of the nitrogen, in the form of nitrate of soda, in one or two later applications.

The plats, each consisting of four rows 136 feet long, are separated by blank rows, making just one-twentieth of an acre to each plat.

Fertilizers per acre applied to the experimental plats, Cairo, Ga., 1904.

Plat 1: No fertilizer.

Plat 2: 800 pounds of normal formula, in one application.

Plat 3: 1,200 pounds of normal formula, in one application.

Plat 4: 2,000 pounds of normal formula, in one application.

Plat 5: 1,200 pounds of revised formula, applied at planting; 100 pounds of nitrate of soda, applied June 9; 100 pounds of nitrate of soda, applied July 23.

Plat 6: 800 pounds of normal formula, in two applications, the second on June 9.

Plat 7: 1,200 pounds of normal formula, in two applications, the second on June 9.

Plat 8: 2,000 pounds of normal formula, in two applications, the second on June 9.

Plat 9: 1,200 pounds of revised formula, in one application; 200 pounds of nitrate of soda in three applications, the second on June 9.

Plat 10: 800 pounds of normal formula, in three applications, the second on June 9 and the third on July 23.

Plat 11: 1,200 pounds of normal formula, in three applications, the second on June 9 and the third on July 23.

Plat 12: 2,000 pounds of normal formula, in three applications, the second on June 9 and the third on July 23.

Plat 13: 1,200 pounds of revised formula, in one application.

Plat 14: Acid phosphate alone: 720 pounds per acre, in two applications, the second on June 9.

Plat 15: Potash alone: 120 pounds of muriate of potash per acre, in two applications, the second on June 9.

Plat 16: Ammonia alone: 240 pounds of nitrate of soda per acre, in two applications, the second on June 9.

Plat 17: No fertilizer.

Plat 18: No potash; normal phosphate and ammonia (from nitrate of soda), in two applications.

Plat 19: No ammonia; normal phosphate and potash (from muriate of potash), in two applications.

Plat 20: No phosphate; normal potash (from muriate of potash) and ammonia (from nitrate of soda), in two applications.

Plat 21: No ammonia; normal potash and phosphate from kainit, in two applications.

Plat 22: No potash; normal phosphate and ammonia, the latter from cotton-seed meal, in two applications.

Plat 23: No fertilizer.

Plat 24: 1,200 pounds of revised formula, in one application; 100 pounds of nitrate of soda, June 9; 100 pounds of nitrate of soda, July 23.

Plat 25: Potash alone: 480 pounds of kainit per acre, in two applications.

Plat 26: Ammonia alone: 480 pounds of cotton-seed meal per acre, in two applications.

Plat 27: 800 pounds of normal formula, in two applications, the second on June 9.

Plat 28: 1,200 pounds of normal formula, in two applications, the second on June 9.

Plat 29: 2,000 pounds of normal formula, in two applications, the second on June 9.

Plat 30: 1,200 pounds of normal formula, in one application, leaving out the nitrate of soda, which was applied July 23 at the rate of 120 pounds per acre.

Plat 31: 800 pounds of normal formula, in one application.

Plat 32: 1,200 pounds of normal formula, broadcast.

Plat 33: 2,000 pounds of normal formula, broadcast.

Plat 34: 1,200 pounds of normal formula, in two applications; 5 rows, 3½ feet apart.

Plat 35: 1,200 pounds of normal formula, in two applications; 3 rows, 5 feet apart.

Plat 36: 1,200 pounds of normal formula, in two applications; ribbon cane.

Plat 37: 24 bushels of cotton seed per acre, normal phosphate and potash, in two applications.

Plat 38: 57 bushels of cotton seed per acre, normal phosphate and potash, in two applications.

Plat 39: Double phosphate, normal potash and ammonia, in two applications.

Plat 40: Double potash, normal phosphate and ammonia, in two applications.

Plat 41: Double ammonia, normal phosphate and potash, in two applications.

Plat 42: No fertilizer.

The fertilization of the 42 plats on field B was exactly the same as that recorded above for the corresponding plats of field A. Experiments were made on additional plats as follows: .

Fertilizer applied to additional plats in field B.

Plat 43: 800 pounds of Peruvian guano per acre, in two applications.

Plat 44: 1,200 pounds of Peruvian guano per acre, in two applications.

Plat 45: 800 pounds of Peruvian guano per acre, in two applications.

Plat 46: 1,200 pounds of Peruvian guano per acre, in two applications.

Field B is rather poor sandy land, which has been long in cultivation. It was in velvet beans in 1903, giving a small growth of vines. In plat 35 of this field the fertilizer was put in the furrow in 4-foot rows, inadvertently, before the rows were changed to 5-foot rows. After the fertilizer was put out new rows were made 5 feet apart, and the cane was planted in the same; therefore the first application of the fertilizer was not made in the row with the cane, but to one side. The second application was put on in the usual way.

Plat 42 of field A had no fertilizer at first, but by mistake, when making the second application on June 9, the following fertilizers were applied: 18 pounds of acid phosphate, 3 pounds of muriate of potash, and 12 pounds of nitrate of soda.

All second applications were made on June 9 and third applications on July 23.

NOTES ON SEASON, GROWTH OF CANE, CULTIVATION, ETC.

March 10: Planted the cane on all plats.

March 29: Cane coming up nicely; no rain since planting.

April 9–11: Showers.

April 14: Nearly perfect stand.

April 26: Showers.

May 14: Suckering slowly on account of dryness; color, good.

June 9: Fairly plentiful rains, breaking the drought. Weather has been too dry, cool, and windy for six weeks. Cane has not grown much, but has good color, and there is a good stand, the plants having suckered well. I am now putting dirt to cane to prevent further suckering. The cane is about 30 inches high on an average, with blades nearly lapping in the middles. Cultivation has been frequent with weeders and sweeps, which have prevented the cane from turning yellow during the drought.

June 22: Light showers.

July 2: Plentiful rains.

July 23: Last application of fertilizer put round cane. Rains have been frequent during July, and cane is growing very fast.

July 27: Laid cane by, with three sweeps furrows to the row.

August 8: It has rained nearly every day for the last ten days. Cane is growing fast. Jointed to a height of 12 to 24 inches.

Table VI.—*Condition of cane crop on the different plats as observed early in June, and height of canes on July 30 at Cairo, Ga., 1904.*

FIELD A.[a]

Plat No.	June 7 and 9.			July 30.	Plat No.	June 7 and 9.			July 30.
	Stand.[b]	Color.[b]	Size.[b]	Height.		Stand.[b]	Color.[b]	Size.[b]	Height.
				Inches.					*Inches.*
1	85	90	90	50	22	100	100	100	62
2	95	95	95	62	23	95	95	95	55
3	95	98	98	64	24	100	100	98	65
4	90	95	95	68	25	90	95	90	58
5	95	95	93	63	26	90	90	90	58
6	95	93	93	58	27	85	95	90	59
7	92	95	93	62	28	95	95	98	62
8	92	95	93	64	29	95	95	98	65
9	92	95	95	61	30	93	95	95	63
10	92	90	90	60	31	95	95	95	63
11	92	90	90	60	32	93	95	93	64
12	95	93	90	61	33	92	95	95	64
13	95	95	93	63	34	95	95	95	60
14	95	90	90	59	35	95	95	95	61
15	95	93	93	54	36	90	95	93	62
16	95	93	90	57	37	93	95	92	61
17	90	85	85	55	38	93	95	93	62
18	95	90	90	58	39	93	95	93	63
19	95	95	93	61	40	90	95	92	63
20	95	95	93	54	41	92	95	92	60
21	95	95	95	60	42	92	85	87	54

FIELD B.[c]

1	85	85	85	44	24	95	95	90	54
2	90	90	90	58	25	95	90	88	46
3	95	93	93	59	26	95	95	92	48
4	95	93	93	60	27	85	90	90	53
5	95	95	95	60	28	92	92	92	54
6	90	90	90	54	29	92	95	95	55
7	92	90	90	49	30	95	95	95	57
8	95	95	92	62	31	93	95	95	56
9	90	95	90	58	32	98	95	95	56
10	92	95	90	53	33	90	95	95	56
11	95	95	95	58	34	90	95	90	53
12	92	93	90	56	35	87	95	87	54
13	87	93	90	56	36	90	95	90	60
14	85	85	85	50	37	87	95	90	60
15	90	85	87	48	38	95	95	92	61
16	90	85	87	45	39	95	95	92	60
17	90	85	85	46	40	90	95	90	58
18	90	90	90	50	41	95	95	93	61
19	95	90	93	52	42	90	85	85	47
20	90	90	90	46	43	95	95	93	58
21	90	90	90	53	44	95	95	93	58
22	95	95	92	54	45	95	95	95	59
23	90	90	85	49	46	95	95	95	61

[a] Observations on all plats in field A were made on June 7.

[b] On basis of 100 as perfect.

[c] Observations on plats 1 to 10 were made on June 7; on plats 11 to 46, on June 9.

TABLE VII.—*Results of fertilizer experiment with sugar cane, Cairo, Ga., 1904.*

Plat No.	Fertilizer.	Yield of cane per acre.		Sucrose.		Reducing sugar.		Purity.		Condition, June 7-9, on scale of 100.								Serial No.	
										Stand.		Color.		Size.		Height.			
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
	PLATS IN GROUPS.	*Tons.*	*Tons.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*									*In.*	*In.*		
1	No fertilizer	12.40	4.60	14.38	12.36	1.08	1.53	91.1	83.2	85	85	90	85	90	85	50	41	3490	3532
17	.....do	17.45	2.50	12.98	12.98	1.28	1.75	85.0	93.4	90	90	85	85	85	85	55	46	3506	3518
23	.....do	15.15	6.90	14.31	11.47	1.00	1.33	89.4	81.5	95	90	95	90	95	85	55	49	3512	3554
42	.....do	18.30	3.55	14.61	12.43	1.05	1.78	92.4	88.2	92	90	85	85	87	85	54	47	3531	3572
	Average	15.82	4.39	14.07	12.31	1.10	1.60	89.5	86.6	......	......	......	......	......	......	......	......	....	....
2	800 pounds normal formula; 1 application	24.75	14.30	15.18	14.45	.85	.82	92.7	91.1	95	90	95	90	95	90	62	58	3491	3533
3	1,200 pounds normal formula; 1 application	28.00	17.50	14.76	14.32	.95	1.20	91.4	90.5	95	95	98	93	98	93	64	59	3492	3534
4	2,000 pounds normal formula; 1 application	27.10	21.95	14.00	14.54	1.23	.93	85.4	89.0	90	95	95	93	95	93	68	60	3493	3535
	Average	26.62	17.22	14.65	14.44	1.01	.98	89.8	90.2	......	......	......	......	......	......	......	......	....	....
6	800 pounds normal formula; 2 applications	20.35	11.45	14.86	15.06	.94	.96	91.9	93.2	95	90	93	90	93	90	58	54	3495	3537
7	1,200 pounds normal formula; 2 applications	22.90	18.60	15.03	14.89	.94	1.13	92.6	91.9	92	92	95	90	93	90	62	49	3496	3538
8	2,000 pounds normal formula; 2 applications	27.25	23.75	14.63	14.53	1.02	1.23	90.7	90.0	92	95	95	95	93	92	64	62	3497	3539
	Average	23.50	17.93	14.84	14.83	.93	1.10	91.7	91.7	......	......	......	......	......	......	......	......	....	....
10	800 pounds normal formula; 3 applications	19.05	17.50	15.16	14.08	.87	1.02	92.7	86.0	92	92	90	95	90	90	60	53	3499	3541
11	1,200 pounds normal formula; 3 applications	23.45	20.40	13.22	13.71	1.42	1.51	86.3	86.7	92	95	90	95	90	95	60	58	3500	3542
12	2,000 pounds normal formula; 3 applications	28.60	24.55	14.02	13.13	1.10	1.49	86.4	86.2	95	92	93	93	90	90	61	56	3501	3543
	Average	23.70	20.82	14.13	13.61	1.13	1.35	91.8	86.3	......	......	......	......	......	......	......	......	....	....
27	800 pounds normal formula; 2 applications	20.25	18.65	14.24	14.58	1.20	1.29	89.3	90.7	85	85	95	90	90	90	59	53	3516	3558
28	1,200 pounds normal formula; 2 applications	26.05	20.80	15.11	13.53	1.00	1.56	90.5	87.1	95	92	95	92	98	92	62	54	3517	3559
29	2,000 pounds normal formula; 2 applications	29.25	23.40	13.77	13.95	1.27	1.13	89.0	88.6	95	92	95	95	98	95	65	55	3518	3560
	Average	25.20	20.95	14.37	14.02	1.16	1.33	89.6	89.7	......	......	......	......	......	......	......	......	....	....
31	800 pounds normal formula; 1 application	23.20	15.55	14.76	13.82	1.02	1.16	91.4	87.9	95	93	95	95	95	95	63	56	3520	3562
32	1,200 pounds normal formula; 1 application	27.90	18.95	14.33	14.08	1.09	1.28	88.8	89.2	93	98	95	95	93	95	64	56	3521	3563
33	2,000 pounds normal formula; 1 application	28.20	25.90	13.22	13.96	1.39	1.30	82.0	89.2	92	90	95	95	95	95	64	56	3522	3564
	Average	26.43	20.13	14.10	13.95	1.17	1.25	87.4	88.8	......	......	......	......	......	......	......	......	....	....
5	1,200 pounds revised formula plus 200 pounds nitrate of soda in 2 later applications	28.30	17.55	14.60	14.58	.94	1.14	90.7	89.0	95	95	95	95	93	95	63	60	3494	3536

9	1,200 pounds revised formula plus 200 pounds nitrate of soda in 3 applications.	24.60	19.85	14.38	15.74	1.05	1.52	91.1	90.7	92	90	95	95	95	90	61	58	3498	3540
13	1,200 pounds revised formula; 1 application	25.20	17.80	15.21	14.17	.91	1.25	94.5	90.4	95	87	95	93	93	90	63	56	3502	3544
24	1,200 pounds revised formula plus 200 pounds nitrate of soda in 2 later applications	28.15	20.05	14.02	12.45	.99	1.47	88.6	82.2	100	95	100	95	98	90	65	54	3513	3555
	Average	26.56	18.81	14.55	14.31	.97	1.35	91.2	88.1	......	......	......	......	......	......	......	......	....	....
	MISCELLANEOUS PLATS.																		
14	720 pounds acid phosphate; 2 applications; second, June 9	20.20	11.75	13.78	13.35	1.27	1.23	87.3	87.0	95	85	90	85	90	85	59	50	3503	3545
15	120 pounds KCl; 2 applications; second, June 9	20.10	6.50	14.10	12.92	1.24	1.33	88.7	85.4	95	90	93	85	93	87	54	48	3504	3546
16	240 pounds $NaNO_3$; 2 applications; second, June 9	20.10	4.95	13.10	11.63	1.61	1.55	79.4	81.1	95	90	93	85	90	87	57	45	3505	3547
18	No potash; normal phosphate and ammonia (ammonia from $NaNO_3$); 2 applications	23.00	9.60	12.46	13.78	1.48	1.04	82.2	93.4	95	90	90	90	90	90	58	50	3507	3549
19	No ammonia; normal phosphate and potash (potash from KCl); 2 applications	26.15	11.40	14.34	13.97	1.19	1.03	89.4	89.2	95	95	95	90	93	93	61	52	3508	3550
20	No phosphate; normal potash (from KCl) and ammonia (from $NaNO_3$); 2 applications	20.80	6.05	13.73	13.82	1.30	1.17	86.2	94.0	95	90	95	90	93	90	54	46	3509	3551
21	No ammonia; normal phosphate and potash (from kainit); 2 applications	23.70	15.85	13.63	14.36	1.21	1.23	86.1	90.0	95	90	95	90	95	90	60	53	3510	3552
22	No potash; normal phosphate and ammonia (from c. s. meal); 2 applications	21.50	14.75	13.94	11.94	1.13	1.48	87.4	77.2	100	95	100	95	100	92	62	54	3511	3553
25	Potash alone; 480 pounds kainit; 2 applications	17.10	10.45	15.37	13.42	.70	1.36	96.0	85.9	90	95	95	90	90	88	58	46	3514	3556
26	Ammonia alone; 480 pounds c. s. meal; 2 applications	16.10	10.20	14.36	12.87	.98	1.53	91.1	83.8	90	95	90	95	90	92	58	48	3515	3557
30	1,200 pounds normal formula, lacking $NaNO_3$, which was applied July 23, 120 pounds	26.55	21.70	13.85	13.88	1.23	1.28	88.0	87.4	93	95	95	95	95	95	63	57	3519	3561
34	1,200 pounds normal formula; 2 applications; 5 3½-foot rows	27.10	21.00	13.16	15.43	1.51	1.60	83.0	95.8	95	90	95	95	95	90	60	53	3523	3565
35	1,200 pounds normal formula; 2 applications; 3 5-foot rows	23.70	15.15	13.32	....	1.42	......	86.4	......	95	87	95	95	95	87	61	54	3524	....
36	1,200 pounds normal formula; 2 applications; ribbon cane	25.60	....	13.19	14.34	1.49	1.53	86.3	89.4	90	90	95	95	93	90	62	60	3525	3566
37	24 bushels c. s. meal; normal phosphate and potash; 2 applications	25.30	21.85	13.92	13.81	1.10	1.17	88.6	88.5	93	87	95	95	92	90	61	60	3526	3567
38	57 bushels c. s. meal; normal phosphate and potash; 2 applications	26.75	24.25	13.60	13.86	1.34	1.21	88.9	89.6	93	95	95	95	93	92	62	61	3527	3568
39	Double acid phosphate; normal potash and ammonia; 2 applications	30.35	21.95	13.32	14.32	1.37	1.16	87.5	89.8	93	95	95	95	93	92	63	60	3528	3569
40	Double potash; normal phosphate and ammonia; 2 applications	28.95	25.00	13.61	15.36	1.33	1.10	87.7	97.2	90	90	95	95	92	90	63	58	3529	3570
41	Double ammonia; normal phosphate and potash; 2 applications	24.75	16.25	13.33	15.18	1.39	1.00	87.5	96.7	92	95	95	95	92	93	60	61	3530	3571
	Average	23.57	14.93	13.69	13.79	1.28	1.28	87.25	88.96	......	......	......	......	......	......	......	......	....	....

TABLE VII.—*Results of fertilizer experiment with sugar cane, Cairo, Ga., 1904*—Continued.

Plat No.	Fertilizer.	Yield of cane per acre.		Sucrose.		Reducing sugar.		Purity.		Condition, June 7 9, on scale of 100.								Serial No.	
										Stand.		Color.		Size.		Height.			
		Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.	Field A.	Field B.
	SPECIAL PLATS ON FIELD B.	*Tons.*	*Tons.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*									*In.*	*In.*		
43	800 pounds Peruvian guano; 2 applications..	......	13.50	......	14.92	......	1.32	......	95.6	......	95	......	95	......	93	......	58	......	3573
45	....do....	......	14.10	......	14.48	......	1.03	......	87.9	......	95	......	95	......	95	......	59	......	3575
44	1,200 pounds Peruvian guano; 2 applications.	......	17.55	......	15.00	......	.90	......	91.5	......	95	......	95	......	93	......	58	......	3574
46	....do....	......	15.60	......	15.02	......	.84	......	91.5	......	95	......	95	......	95	......	61	......	3576
	Average....	......	15.19	......	14.85	......	1.02	......	91.62	......	......	......	......	......	......	......	......	......	......

Discussion of the Data.

One of the most remarkable facts which is presented in the study of the data is the great yield of cane from the plats on field A, where no fertilizer was used. The average yield on plats 1, 17, 23, and 42 of field A was 15.82 tons per acre, while on the same numbers in field B the yield was only 4.39 tons per acre. Apparently the only difference in the conditions between the two fields is found in the fact that cowpeas had been grown upon field A, thus furnishing a somewhat abundant supply of nitrogen for the succeeding crop of cane. The percentage of sucrose in the canes from the unfertilized plats in field A was very considerably higher than in field B, the figures being 14.07 and 12.31, respectively. The reducing sugar also was less on these plats in field A, namely, 1.10 per cent, as compared with 1.60 per cent from the plats on field B. Finally, the purity of the juices on the plats for field A was higher, namely, 89.5, as compared with 86.6. These data show the great superiority of field A in every respect for producing a crop of cane.

A comparison of plats 2, 3, and 4 is also interesting. It is seen that field A responded to the influence of fertilizers almost as well as field B. The average yields of the three plats under the influence of the normal formula fertilizer were 26.62 and 17.22 tons, respectively, per acre. The average increase per acre on field A under the influence of the fertilizer was 10.8 tons, while the average increase in field B was 12.83 tons. These data show that the effect of the fertilizer on the poorer soil was more marked than upon the richer. It may be seen, too, that the percentage of sugar in the cane grown on the poorer soil reached almost the same magnitude as that of the cane grown on field A; and the same is true of the reducing sugar and of purity.

GENERAL COMMENT ON RESULTS AT CAIRO, 1904.

The results on plats 6, 7, and 8 were obtained with exactly the same quantity of fertilizer as was used on plats 2, 3, and 4, but it was applied at two different times. In this instance the application on two dates appears to have diminished the yield on field A 3 tons per acre on an average and to have increased by 0.7 of a ton per acre the yield on field B. On plats 10, 11, and 12 the same quantities of fertilizer were used as on the plats of the two series just discussed, but three applications were made. The results show but little variation from the yields on field A with the same quantity of fertilizers in two applications; but there was an increase of almost 3 tons per acre in the yield on field B. On plats 27, 28, and 29 was tried a duplicate experiment of that conducted on plats 6, 7, and 8, namely, the application of the fertilizer at two different times. The yield on field A is seen to average 1.7 tons higher than on plats 6, 7, and 8, while the yield on field B is 3 tons greater. On plats 31, 32, and 33 the experiment was a duplicate of that conducted on plats 2, 3, and 4. The yield on field A in the two experiments was almost the same. The yield on field B, however, was almost 3 tons greater in the latter.

On plats 2, 3, and 4 there was an increase in yield on field A when the quantity of fertilizer was raised from 800 pounds to 1,200 pounds per acre, but a decrease when it was increased to 2,000 pounds. On field B there was an increase regularly with the increase in the amounts of fertilizer. In case of plats 31, 32, and 33 there was a regular increase in yield on both fields with the increase in the amount of fertilizer. On plats 6, 7, and 8 there was a regular increase in yield from both fields with the increase in the amounts of fertilizer, and the same is true of plats 27, 28, and 29, on which the experiment was duplicated. On plats 10, 11, and 12 there was also an increase in yield with an increase in amount of fertilizer.

On plats 5, 9, 13, and 24 the modified or revised normal formula, described in the report of Mr. Roddenbery, was used in combination with the other fertilizing materials mentioned in each case. Twelve hundred pounds of the revised normal fertilizer to the acre was used on each plat. On plat 5, where, in addition to this, 200 pounds of sodium nitrate was used in two applications, the yields obtained were 28.30 tons per acre on field A and 17.55 on field B. On plat 9, where the whole of the sodium nitrate was applied at once, there was a decreased yield on field A and an increased yield on field B. On plat 13, where the revised normal formula was used alone, a yield of 25.2 tons per acre was obtained on field A and 17.8 tons on field B. On plat 24, where 200 pounds of sodium nitrate was employed in addition to the revised normal formula in two applications, thus making the experiment a duplicate of that on plat 5, almost the same result was obtained on field A, while an increase of 2.5 tons resulted on field B.

The average yield for the miscellaneous plats (excluding Nos. 43, 44, 45, and 46 of field B, which have no corresponding numbers in field A) was for field A 23.57 tons per acre and for field B 14.93 tons per acre. The character of fertilization in both fields was exactly the same, and the difference in yield must therefore be ascribed to the greater natural fertility of field A.

The general average yield of all the plats on both fields was 19.64 tons per acre. The average sugar content of the juice in the samples from both fields was 13.71 per cent. The average percentage of reducing sugar in the juices from the plats of both fields was 1.2 per cent, and the average purity of juices from the plats of both fields was 87.68. These data show that the general character of the cane produced is such as would have produced a satisfactory yield of sugar had the juices been worked for that purpose.

An interesting comparison can also be made in regard to the particular fertilizers used on the different miscellaneous plats. The use of acid phosphate alone at the rate of 720 pounds per acre on plat 14—two applications, the second one applied on June 9—increased the yield in field A on an average 4.4 tons per acre, while the increase on field B amounted to over 7 tons per acre. The use of potassium chlorid alone at the rate of 120 pounds per acre on plat 15 increased the yield on field A 4.3 tons per acre and on field B a little over 2 tons per acre. The use of 240 pounds of nitrate of soda alone on plat 16 increased the yield on field A 4.3 tons per acre, while the increase on field B was only a little over a half ton per acre.

It will not be necessary to go into detail in regard to the remaining plats, as the effect of the different fertilizers upon the yield can be easily ascertained by studying the data in Table VII.

REPORT ON EXPERIMENTS AT WAYCROSS, GA., 1904.

The cultural experiments conducted at Waycross, Ga., were under the supervision of G. R. Youmans, special agent. The plan of the plats and application of the fertilizers was the same as that under which the work at Cairo was done. The experimental plats in 1903 were entirely ruined by a prolonged period of very wet weather, during which the plats were under water, and the young cane was thus destroyed. The report of the field work for 1904 is as follows:

TREATMENT OF CROP AND FERTILIZATION.

On February 20 the land was plowed up, and the cane was planted from March 15 to 20, the rows being laid off with an 8-inch opening plow, and the fertilizer placed in this furrow, after which a small plow was run through to mix the fertilizer thoroughly with the soil, as germination might be prevented if the cane came too much in contact with the fertilizer. The cane was cut in pieces about 18 inches long, which were dropped lengthwise in the row, with 4 inches of space between, and then covered 2 to 3 inches deep with a small plow. About the time the cane began coming up a weeder was run over the field both ways to keep the surface of the earth in good condition. This style of cultivation was continued until the cane was 12 to 15 inches high. After that time it was plowed every 15 or 20 days until the cane was too large for a horse to pass between the rows.

The following table shows the fertilizers applied to the several plats and the yields of cane secured:

TABLE VIII.—*Fertilization of experimental plats and yields of cane thereon, Waycross, Ga., season of 1904.*

Plat No.	Fertilizer applied.	Number of applications.	Yield of cane per acre.
			Tons.
1	2,000 pounds of normal formula	3	12.98
2	2,000 pounds of cotton-seed meal	2	14.84
3	No fertilizer	....	3.44
4	2,000 pounds of normal formula	2	17.24
5	1,200 pounds of normal formula	2	18.18
6	800 pounds of normal formula	2	16.74
7	480 pounds of cotton-seed meal	2	7.50
8	480 pounds of kainit	2	6.24
9	720 pounds of acid phosphate	2	5.04
10	2,000 pounds of cotton-seed meal	1	17.74
11	720 pounds of acid phosphate plus 480 pounds of cotton-seed meal	2	9.04
12	720 pounds of acid phosphate plus 480 pounds of kainit	2	8.10
13	120 pounds of potassium chlorid plus 120 pounds of nitrate of soda	2	6.04
14	720 pounds of acid phosphate plus 120 pounds of potassium chlorid	2	10.04
15	720 pounds of acid phosphate plus 240 pounds of nitrate of soda	2	6.66
16	No fertilizer	....	2.70
17	....do	....	5.74
18	800 pounds of normal formula	1	16.62
19	1,200 pounds of normal formula	1	20.94
20	2,000 pounds of normal formula	1	28.94
21	2,000 pounds of cotton-seed meal	2	18.46
22	800 pounds of normal formula	2	20.50
23	1,200 pounds of normal formula	2	18.50
24	2,000 pounds of normal formula	2	20.66
25	2,000 pounds of cotton-seed meal	3	17.58
26	800 pounds of normal formula	3	20.64
27	1,200 pounds of normal formula	3	24.16
28	2,000 pounds of normal formula	3	27.28
29	720 pounds of acid phosphate	2	17.90
30	No fertilizer	....	5.04
31	120 pounds of potassium chlorid	2	2.96
32	240 pounds of nitrate of soda	2	8.34

QUALITY OF THE CANE PRODUCED.

The following table shows the character of the juice extracted from the cane produced on the experimental plats:

TABLE IX.—*Analyses of juices from sugar cane grown on experimental plats, Waycross, Ga., 1904.*

Serial No.	Plat No.	Density.	Sucrose.	Reducing sugar.	Purity.
		°Brix.	*Per cent.*	*Per cent.*	*Per cent.*
3378	1	15.80	12.74	1.62	80.40
3379[a]	2				
3380	3	14.10	10.94	1.71	77.30
3381	4	15.10	12.39	1.61	82.10
3382	5	15.80	13.24	1.45	83.50
3383	6	15.50	12.80	1.63	82.60
3384	7	15.10	11.97	1.70	79.50
3385	8	14.60	11.50	1.75	79.90
3386	9	14.30	11.53	1.62	80.50
3387	10	13.80	10.90	1.85	79.00
3388	11	13.00	9.85	1.72	76.10
	[a]12				
3389	13	15.10	11.66	1.46	77.40
3390	14	14.70	11.08	1.86	75.50
3396	15	14.80	11.66	1.77	79.10
3397	16	13.40	9.27	2.27	69.40
3398	17	14.50	11.27	1.92	78.00
3399	18	15.70	13.00	1.54	82.80
3400	19	14.60	11.76	1.89	80.80
3401	20	13.90	10.73	2.12	77.00
3405	21	15.00	11.40	2.03	76.00
3406	22	15.50	12.53	1.71	80.70
	[b]23				
3407	24	14.90	11.31	2.27	75.90
3408	25	15.30	11.96	2.03	78.40
3409	26	14.60	10.84	2.36	74.00
3412	27	14.20	10.31	2.67	72.50
3413	28	14.50	10.95	2.28	75.90
3414	29	15.30	12.38	1.95	81.00
3415	30	15.10	12.10	1.64	80.20
3416	31	16.00	13.20	1.53	82.50
3417	32	16.10	13.72	1.24	85.10
Average	......	14.84	11.69	1.83	78.78

[a] No analysis made on account of sample being broken in transmission by mail to the Bureau of Chemistry.

[b] Sample missing.

CHARACTER OF THE SOILS USED IN THE EXPERIMENTS.

Analyses of the soils of the experimental plats, both at Waycross and Cairo, show that they are composed almost exclusively of sand. The quantity of insoluble matter—matter which does not dissolve in boiling concentrated hydrochloric acid—is from 97 to 98 per cent of the total weight of the soil.

There is little difference between the soil and subsoil in regard to solubility; both are composed principally of sand. At Waycross the largest quantity of insoluble matter was found in the second subsoil, namely, 98.33 per cent, and the smallest quantity in the first soil, namely, 96.55 per cent.

The total volatile matter—the matter escaping on ignition, which includes water in composition, carbonic acid in combination, and organic matter—is highest in the first of the Waycross soils, namely, 2.32, and lowest in the second subsoil, namely, 0.93. A very large part of the soluble matter in these soils is composed of iron, which takes but little part in plant nutrition. The actual quantities of the readily available plant foods in these soils are extremely minute. The amount of lime falls as low as 0.02 per cent in some of the soils, and the largest percentage, which was found in one of the subsoils at Waycross, was only 0.15 per cent. Magnesia is only found as a slight trace in the Waycross soils and less than 0.03 per cent in the Cairo soils. The potash is very low in the Waycross soils, and only a little over 0.1 per cent in the Cairo soils. Phosphoric acid is also very deficient in both soils, the Waycross soils having a slightly larger percentage. Nitrogen is relatively more abundant than potash and phosphoric acid, but still very deficient, being practically the same in both soils, and as a rule less than 0.05 per cent. It is evident that it is only by reason of a high degree of availability that such small quantities of plant food can produce even as good yields as were secured from the plats where no fertilizer was applied.

The potential fertility of these soils is extremely low, and therefore any plan which looks to the continuous growing of crops upon them must be based upon a judicious method of fertilization. The object in feeding soils of this kind is, of course, to grow a paying crop at the smallest possible expense of fertilizing materials. For this reason, bringing the land into condition to grow leguminous crops, such as cowpeas and velvet beans, affords one of the cheapest and best methods of increasing the stores of nitrogen.

In so far as phosphoric acid and potash are concerned, it is evident that the chief supplies must come from commercial fertilizers. For these reasons the series of studies of fertilizers conducted in the plat experiments becomes of high scientific and practical importance. While it is not claimed that experiments covering two or three years can lead to the most satisfactory conclusions, it is evident that, in the work which has been conducted under the supervision of Mr. Roddenbery, considerable progress has been made toward securing information of the highest practical value to the cane grower. Sugar cane is a crop which, fortunately, makes very moderate demands on the stores of plant food, considering the weight of organic matter produced. Producing, as it does, no seeds, its demand for nitrogenous fertilizer is reduced to a minimum. There are apparently but few crops which can produce such a quantity of organic matter with so small an expenditure of the three essential elements of food, namely, phosphoric acid, potash, and nitrogen. In the experiments which have been conducted, apparently more phosphoric acid has been used than the physiological requirements of the plant demand, and in future experiments studies will be made to see if this quantity can be safely reduced without financial loss in the making of a crop.

Unfortunately in a soil so granular as that represented, where leaching takes place with such facility, and especially where the quantity of clay and humus is extremely small, soluble fertilizing materials must rapidly disappear under the influence of heavy rains. It therefore seems to be the part of wisdom so to balance the ration of fertilizers added as to practically supply the demand for a single crop, without expecting to carry over to another year a reserve for future use. In spite of this practice, however, it is evident from the experiments described with stubble cane that a considerable amount of benefit accrues to the subsequent crop from the original application of the fertilizer.

These are practical questions which underlie, to a large extent, the successful manufacture of table sirup, which must, of course, depend for its ultimate success upon scientific and economic principles of applied agriculture.

The following tables contain the data resulting from analyses of the soils at Cairo and Waycross, Ga., and of the fertilizers employed. The data in tables XII and XIII represent the composition of the soils and fertilizers for the work as planned for 1903; but, as already explained, on account of unusual weather conditions the experiment at Waycross was a failure in that year. The soil data in Table XII, however, show the general character of the soil near Waycross, and the fertilizer data (Table XIII) the character of the fertilizers used at Waycross in 1904, which were mixed according to the directions for 1903.

TABLE X.—*Composition of soils and subsoils from sugar-cane experimental plats at Cairo, Ga., 1904.*

Description.	Serial No.	Insoluble (by difference).	Volatile.	Alumina and iron.	Calcium.	Magnesium.	Potash (K_2O.)	Phosphoric acid.	Nitrogen.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Field A:									
Soil	3127	92.383	3.50	3.85	0.04	0.025	0.14	0.02	0.042
Subsoil	3128	87.097	3.50	9.20	.02	.028	.11	.01	.035
Field B:									
Soil	3125	94.640	2.55	2.60	.02	.028	.11	.01	.042
Subsoil	3126	88.600	3.36	7.78	.02	.025	.17	.01	.035

TABLE XI.—*Composition of fertilizers used at Cairo, Ga., 1904.*

Description.	Serial No.	Phosphoric acid.			Potash (K_2O).	Nitrogen.
		Total.	Insoluble.	Available.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cotton-seed meal	2892	2.45	....	....	....	5.88
Kainit	2893	....	....	....	11.28	....
Nitrate of soda	2894	....	....	....	....	15.76
Normal formula	2895	7.97	0.91	7.06	5.48	2.72
Acid phosphate	2896	15.52	.36	15.16	....	....
Muriate of potash	2897	....	....	....	49.40	....
Peruvian guano	2898	22.16	10.58	11.58	4.19	2.88

TABLE XII.—*Analyses of soils used in sugar-cane experiment at Waycross, Ga., 1903.*

Description.	Serial No.	Insoluble.	Volatile.	Iron.	Calcium.	Magnesium.	Potash (K_2O).	Phosphoric acid.	Nitrogen.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per ct.*
Soil	2173	96.55	2.32	1.07	0.07	Slight trace.	0.02	0.04	0.063
Subsoil	2174	97.51	1.72	.55	.15	.....do......	.02	.03	.049
Soil	2175	97.37	1.27	1.17	.06	.....do......	.02	.02	.035
Subsoil	2176	98.33	.93	.57	.02	.....do......	.10	.02	.028

TABLE XIII.—*Analyses of fertilizers used at Waycross, Ga., 1904.*

Description.	Serial No.	Phosphoric acid.			Potash (K_2O).	Nitrogen.
		Total.	Insoluble.	Available.		
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Normal formula	1763	10.84	1.75	9.09	5.69	2.75
German kainit used	1764	....	....	....	11.96	....
Acid phosphate used	1765	18.82	1.02	17.80	....	....
Cotton-seed meal used	1766	2.50	....	....	1.80	5.83
Muriatic acid used	1767	....	....	....	48.95	....
Nitrate of soda used	1768	....	....	....	....	14.93

MANUFACTURING DATA.

INSTALLATION AND OPERATION OF SIRUP FACTORY, WAYCROSS, GA.

WORK OF 1903.

As soon as possible after the appropriation for the fiscal year beginning July 1, 1903, was available, bids were secured for erecting an experimental sirup factory at Waycross, Ga. This point was selected because of superior advantages from its central location and the ease with which it could be reached from various quarters of the sirup-producing area. Satisfactory arrangements were made for the lease of the land on which the factory was to be placed and for the supply of cane for experimental purposes. The usual delays attending the erection of machinery by contract were experienced, although an agent of the Department, Mr. Arthur Given, was kept at Waycross for the purpose of expediting the work as much as possible.

By October 13, the building was finished, the engine and mills were erected, and the setting of the boiler was in progress. There was, however, an immense amount of detail work to be finished, and already at that time the manufacturing season had opened. Every effort was made to push the work of construction as rapidly as possible, but it was found impracticable to even commence the experimental work before November 24. The delays and annoyances incident to the employment of unskilled labor were now encountered, together with the usual defects which practical working of new machinery always reveals. The principal parts of the machinery, especially the mills, were found to give entire satisfaction. Trouble was experienced with the cane and bagasse carrier and the automatic arrangement for feeding the bagasse to the boiler. It was soon discovered also that a single boiler designed for burning bagasse was not well adapted to firing with wood, a necessity for which was at once apparent, owing to the irregular manner with which the work was conducted.

As a result of all these delays not much more could be accomplished the first year than to determine exactly the improvements in the plant which would be advisable for a successful run the following season. Especial attention, therefore, was directed to this point, and Mr. Given was instructed to make a careful record of all the points in the operation of the machinery and the general conduct of the manufacturing work which should receive attention another year. Valuable data, however, were obtained respecting the operation of the bagasse burner, the possibility of using bagasse alone for fuel, the degree of extraction obtained, the relative efficiency of the first and second mills, the possibilities of establishing filters for the semisirup, and the methods of sterilizing barrels, and of securing, as nearly as possible, uniformity in tint and density of the product.

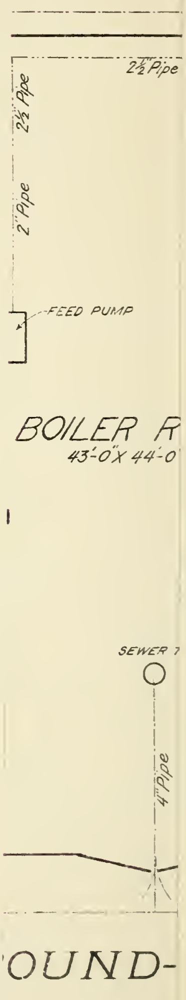
WORK OF 1904.

The changes in the equipment of the factory in 1904 were made under the supervision of Mr. Arthur Given, with the assistance, for a short time, of Dr. G. L. Spencer. The experimental part of the manufacturing work was also under the supervision of Mr. Given, while the commercial features of the work were under the control of Mr. G. R. Youmans, special agent. Mr. Given's report is as follows:

IMPROVEMENTS IN PLANT.

The work of the season of 1903 showed that many alterations and additions were advisable in order that the factory might perform satisfactory work in the most economical manner, and plans were accordingly prepared under the supervision of the Chief of Bureau and bids on the work were obtained. The following additions and alterations were decided upon:

1. To remove the bagasse burner and to put in a new boiler and bagasse burner, as originally designed for the plant.
2. To rebuild the boiler house, as made necessary by the first change.
3. To rebuild and extend the bagasse carrier.
4. To rebuild the cane carrier.
5. To concrete the floors of the mill house and boiler house.
6. To raise and strengthen the floors in the building.
7. To put in standard rotary pumps for handling juice and sirup.
8. To rebuild the low-pressure evaporator.
9. To rebuild the high-pressure evaporator.
10. To rebuild the filters.
11. To put up a crane and track for unloading cane from carts.
12. To take out and repair the settling tanks.


2½" Pipe
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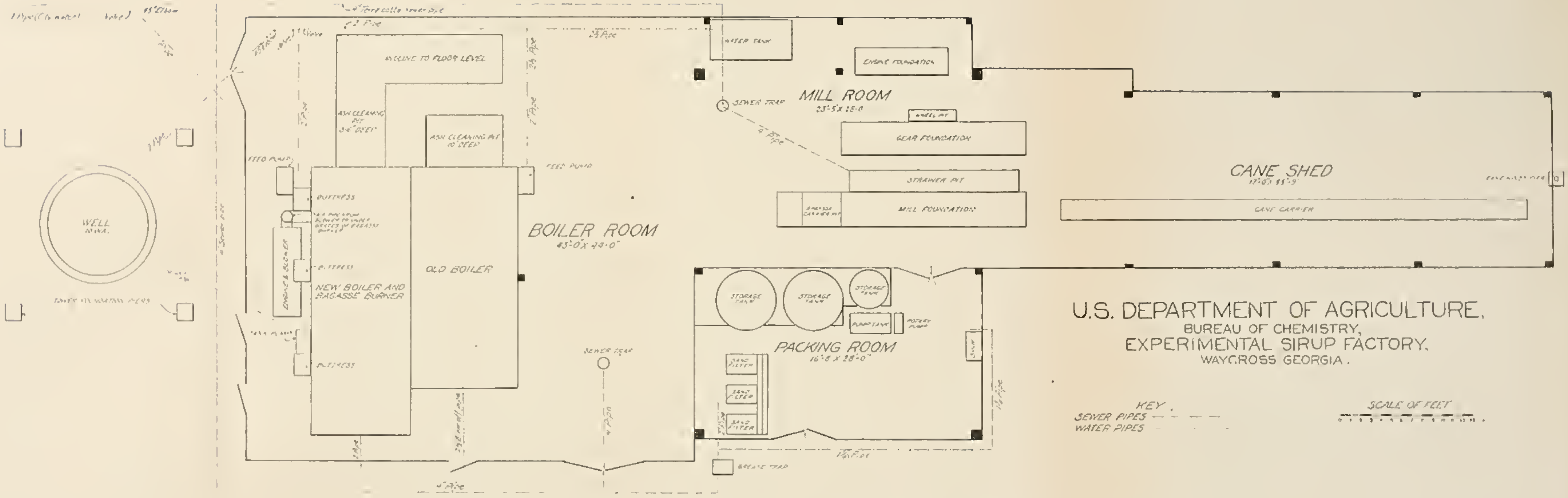
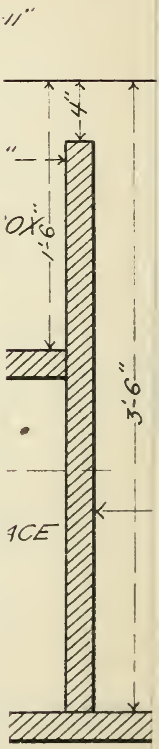


FIG. 1.—GROUND-LINE PLAN, SHOWING BURIED PIPES.



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13. To dig a well for water supply and erect a tank on tower of sufficient height to carry water to the top of the building, so as to lessen the danger from fire.

14. To replace the partition about the laboratory by a stronger and better one.

15. To lower the work tables in the laboratory and put in a new heating coil.

16. To inclose both stairways.

17. To put stronger turn-buckles on the smokestack guy ropes.

18. To get a new turnplate to replace the one broken in No. 2 mill.

19. To fix all swinging shutters and to put fastenings on same.

20. To tighten all leaking joints.

21. To cover all steam, exhaust, and hot-water pipes.

22. To rebuild the hood over the evaporators and provide a means by which to open the ventilator on the roof to permit the escape of steam.

23. To replace the tank outlet valves and plugs by quick-opening straight-way valves.

24. To get two additional steam traps.

25. To have the whole plant wired for electric lights and connected with the Waycross lighting system.

26. To cover the floors of the building with linoleum, carefully cemented so as to be water-tight.

The making of the alterations and additions was in progress by June 20, and the work was practically completed, including the extension of the cane shed, on September 15. In the following week Mr. Chick was detailed from the Washington office to take charge of the pipe work, and successfully carried out that part of the work.

The appearance of the factory, front view as remodeled, is shown in Pl. II. The location of the machinery and apparatus is shown in the three floor plans (figs. 1, 3, and 4).

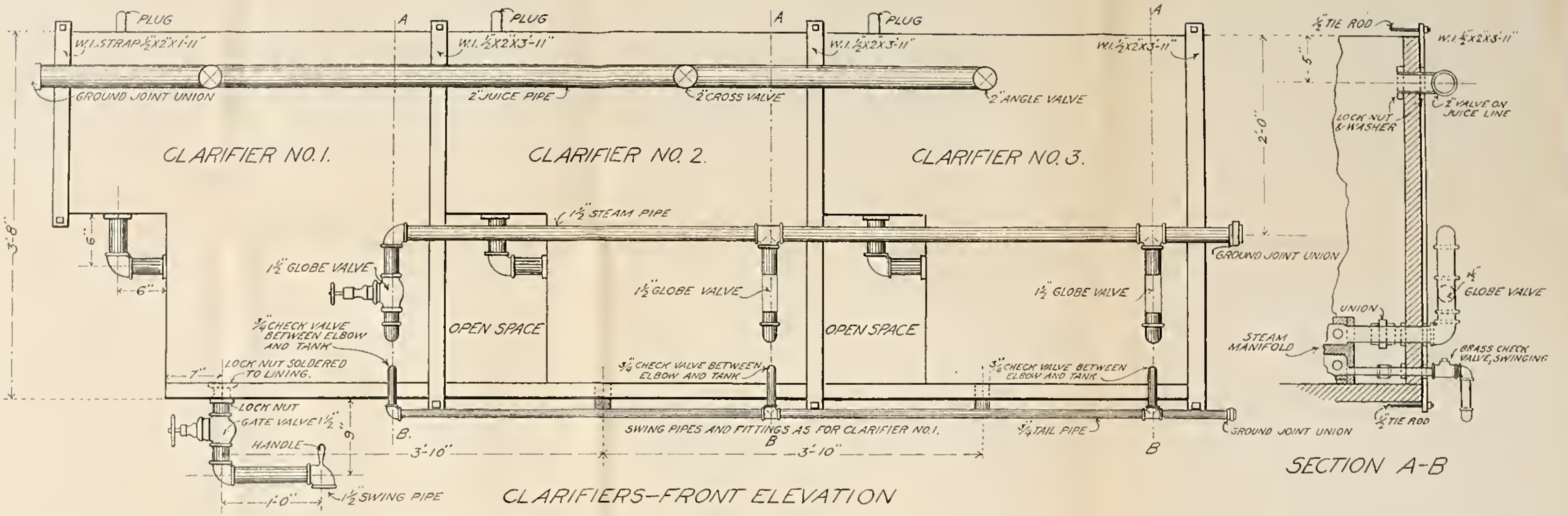
The work of installation was pushed forward as rapidly as possible in order to make a trial run under Doctor Spencer's inspection, and on October 17, although a few small pieces of work remained to be done, a run was successfully made. After finishing the sirup in process of manufacture the work of installation was continued and completed on November 2, the grinding season being opened the following day. The covering of the pipes was purposely delayed until after the factory was started, as leaks might develop which would have to be repaired, thus damaging the covering.

OPERATION OF THE PLANT WITH DESCRIPTION OF MACHINERY AND APPARATUS.

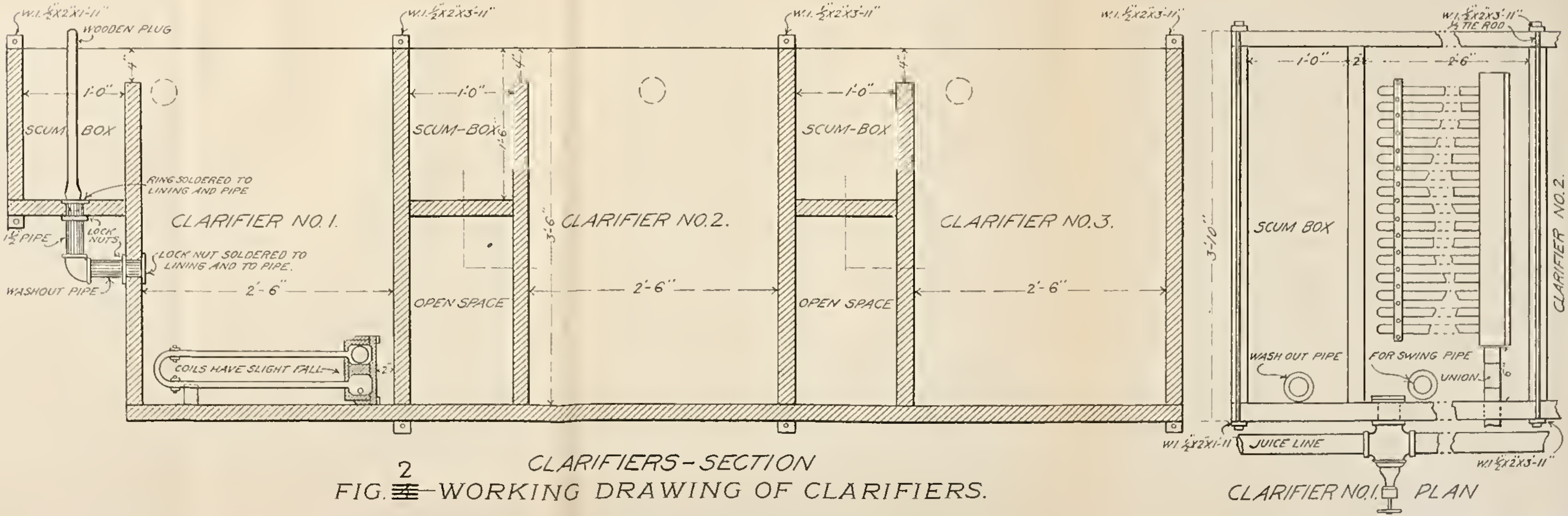
The boilers steamed very easily. The arrangement of the boilers is shown in Pl. III, fig. 1, with the bagasse boiler on the right. The figure also shows the arrangement of the feed pumps and the attachment of the main steam pipe. The plant used about 100 cords of wood during the season in making between 11,000 and 12,000 gallons of sirup. Mr. Roddenbery reports that he used 300 cords in making about 22,000 gallons of sirup. The old boiler was scaled very badly from the use of the city water last year, but the well water used in 1904 did not deposit any new scale, and the old scale in a short time was completely removed.

At first there was a great deal of trouble from foaming, due to a leak in some of the pipes which permitted juice or sirup to get into the water in the pipes and so into the boilers. After some time the main leak was discovered to be through the packing between the cover and body of one of the clarifier manifolds, and it was promptly stopped. There were two other small leaks in the brazed joints of the steam pipes of the low-pressure evaporator, but after the main leak was stopped these gave no serious trouble.

The amount of oil in the condensed water was so small that it was at no time a source of annoyance. This was due in part to the fact that a large part of this water was used for washing the filters, so that much of the oil went to the sewers in that



CLARIFIERS—FRONT ELEVATION



CLARIFIERS-SECTION

CLARIFIER NO. 1. PLAN

FIG. 2—WORKING DRAWING OF CLARIFIERS.

way. The fusible plug was melted out of the old boiler, and the front manhole gasket so burned as to necessitate replacing it. As this leak from the plug only appeared after the boiler was freed from scale by the action of the well water, it would seem probable that the plug might have been melted out last year, but that the scale kept the leak from showing.

Steam was always kept in both boilers, since the frequent interruptions, and the fact that the plant was run only 10 hours a day, made it impossible to keep a sufficient head of steam on the bagasse boiler alone. In making one of the largest runs made, wood was used in the bagasse burner, but without obstructing the chute. As the brick work of the boiler setting became hotter, less and less wood was required, and the last two hours of the run no wood at all was burned. When the plant shut down for the night, there was 100 pounds of steam.

When running regularly, it was quite an easy matter to regulate the steam by the forced draft. The blower and engine worked very well, as they did last year, notwithstanding the fact that several times the engine ran all day, or even for two days, without any lubrication of the cylinder, and often with some of the other oil cups empty. The tank pump and one of the boiler feed pumps were once or twice out of use because of the same lack of care. Owing to the number of pumps, there was no time when the boilers could not be readily supplied with water; whereas, last year, there were several occasions when the fire had to be drawn to keep from injuring the boiler.

Notwithstanding the great lack of rain, the well furnished at all times from 6,000 to 8,000 gallons of water per day, and, though there were times when city water had to be used because the tank was not filled at night, under ordinary circumstances the well furnished all the water needed. This water had a strong taste of lime, which may have been due to the cement walls, but it seemed to be excellent water for the boilers.

All steam connections with pumps were made one size larger than the pump called for, and by this means the trouble experienced last year in getting water into the boilers when the steam was low was avoided. The small Marsh pump used for pumping skimmings worked imperfectly throughout the season.

The engine and the machinery connecting it with the mill are shown in Pl. IV, fig. 1. A new governor was the only piece that had to be furnished for the engine, which, however, should be a reversing engine, as it is often very difficult to slack back the rolls when the mill chokes for any reason. Some difficulty was experienced in keeping the crank pin cool, and a centrifugal oiler is needed.

The front of the mill, showing the attachment of the cane carrier, is illustrated in Pl. IV, fig. 2. By way of contrast, a primitive sugar mill from the Philippine Islands, exhibited at the Louisiana Purchase Exposition, is shown in the frontispiece (Pl. I).

The bagasse carrier and the method of its attachment to the mill are shown in Pl. IV, fig. 1. Bagasse collected on the upper sprockets once and broke five or six links of the chain before the difficulty was discovered. The pit at the bottom of the carrier is not large enough to be cleaned easily, and should be enlarged before another season. Also the take-ups on the carrier, which are at the bottom and in an inconvenient place, should be put at the top. It will be very easy to change this, and with all the take-ups out of the way it is possible that there would be plenty of room to clean out the pit. The bagasse feeder bade fair to give trouble this year, but by changing the bearings of the swinging door, in accordance with Doctor Spencer's suggestion, good results were secured.

The cane hoist was very satisfactory, saving about three-fourths of the time required to unload by hand. Some difficulty was experienced in putting the clutch on the engine shaft, which was a little larger than the bore of the clutch. The shaft was filed down, but caused the only accident of the season before it was finally adjusted. As the first filing was not enough to prevent the clutch from heating a little the engineer undertook to cut the shaft down with emery, and, in so doing, the space between the clutch and shaft was filled with the fine emery and oil. After running for a little over a day in this condition the clutch stuck fast just as a load of cane was being unloaded. Before the engineer could stop the engine the crane was partially wrecked. There was much trouble with the slings used to lift the cane, for if the loaders in the field did not load the cane evenly the bundle of cane would slide out of the sling and have to be piled by hand.

The rotary pump for pumping juice was a failure, through no fault of the device, but because the cane was very sandy, and, as the pipe from the strainer was flush with the lowest part of the strainer box it sucked up all this sand, which quickly cut out the cams of the pump. One pump was entirely disabled in this way and it was thought advisable to put in a steam pump, as a reciprocating pump does not cut as fast as a rotary one. This was done, and there was no more trouble from this source.

The trouble with the cams can be avoided by running the suction pipe from the pump into the strainer from the top and leaving a space for the sand to collect so that it can be scraped out instead of going through the pump. This can be done when putting in the mechanical strainer, and it might be advisable to have both the rotary and steam pumps so as not to run the risk of having to shut down because the juice pump is out of order, as happened several times this year. The rotary used for pumping sirup, after the cams were adjusted, worked just as it should, but it was rather inconvenient at times to be obliged to run the whole mill to pump up a little semisirup. Of course this would not happen if the plant were running twenty-four hours a day.

The clarifiers, three in number, as shown in Pl. III, fig. 2, were placed on the third floor and received the juice from the juice pump. The plan of the clarifiers is seen in the working drawing (fig. 2). These three clarifiers are three divisions of one tank. Each clarifier is nearly square, built of 2-inch hard pine, and lined with copper. Each one has on the left side a scum box to receive the scum from the juice. The juice is heated by a manifold in the bottom, connected with a steam pipe, and with a tail pipe line.

These clarifiers worked well, as they did last year, the only trouble being that the trap is not of sufficient capacity to carry off the water, produced by condensation of steam, fast enough, and so, unless there is a full head of steam and the trap is working just right, the clarifiers are apt to heat rather slowly. It has always been possible to keep up with the mills as long as the trap worked well, but in the two or three cases where it has failed, the mills have had to shut down to wait for the clarifiers. As larger traps are needed for the high-pressure evaporator, and for the first coil of the low-pressure evaporator, the traps that are thrown out of use might well be used on the clarifiers, giving each clarifier its own trap, and so doing away with this difficulty. Under the conditions of the past season, it was necessary to use live steam altogether in the clarifiers, but it should be possible to use low-pressure steam, and with a trap for each tank this would probably be done.

The gate valves on the outlet pipes of the clarifiers were replaced by quick-opening lever valves, as were also the plugs for the washouts of the settling and scum tanks and the globe valves on the outlets of the sirup tanks. They gave no trouble by leakage and saved a great deal of time both in operating the valves and in emptying tanks, the straight full-sized passage adding greatly to the efficiency.

When the plant is in operation the steam is turned on as soon as the coils of the manifold are covered. Usually it takes from twenty to twenty-five minutes to fill a clarifier, though it has been done in eighteen minutes. Each clarifier is filled up to the bottom of the inlet pipe; then the valve of the next one is opened and that of the full clarifier is closed. With full steam on it takes about five minutes to bring the juice to a boil, or to the "crack" as it is termed, when the thick layer of scum breaks and white foam appears through it. At this point the steam is shut off and the blanket of scum is brushed off into the scum box. This is repeated twice, then the juice is brought to a boil and brushed until the foam is clean and white.

The juice is allowed to stand until the next tank is full, when the valve in the outlet pipe is opened and the clean juice is run down to the settling tanks. Around the outlet in the bottom of the clarifier is a loose lead ring about an inch high. The juice is allowed to run to the settling tank until this ring is exposed, then the swing pipe is shifted to the scum tank, the lead ring is pushed aside, and the plug closing the outlet of the scum box is removed, allowing the scum to flow into the clarifier and thence into the scum tank. When the scum has nearly all run out the hose is turned into the scum box and the rest of the scum is washed out with as little water as possible, the sides, bottom, and coils of the clarifier being washed and scrubbed clean. This work is done after the second clarifier is skimmed and while waiting for the third one to fill. In this way the clarifiers are always kept clean and bright and give the best results.

The settling tanks, shown in Pl. V, fig. 1, in the upper right background, are the three compartments of a galvanized-iron vessel 4 by 8 by 3 feet. Each compartment is independent of the others as far as its internal arrangements are concerned. Each has two outlets, one for the clean juice about an inch from the bottom in the middle of the front of the tank, and the other for the settlings or "foots" in one corner of the bottom. The relative position of the settling tanks is shown in the second floor plan (fig. 3). The juice outlet has a lever gate-valve on the outside and a swing joint with a brass pipe, just long enough to clear the back of the tank, fitted with a cylindrical float, which keeps the brass pipe always at the top of the juice and so avoids getting any of the settlings. The "foots" outlet is closed by a quick-opening valve close under the tank. The pipe from this valve leads to the juice tank to be described later.

The clean juice from the clarifiers passes into a trough on top of the settling tanks 6 inches wide and 6 inches deep, which extends across all three tanks. This trough has three openings corresponding to the tanks, and these are stopped by heavy plugs so as to direct the juice into any one or more of the tanks. Each tank holds the same amount as a clarifier, and they are accordingly filled in rotation, like the clarifiers and emptied in the same order so as to give them an equal time to settle. This settling is not of much importance, however, as most of the heavy sediment settles in the clarifiers and passes off with the scum.

The settled juice runs into another trough, extending not only across the fronts of the settling tanks, but to the last compartment of the scum tanks as well. The juice passes from this trough through a 2-inch pipe down under the floor, and over to the farther end of the low-pressure evaporator, shown at the left in Pl. V, fig. 1, where it comes up again and turns over the edge of the evaporator. The settlings are run out once a day and the tanks are thoroughly scrubbed. Last year these tanks were partly rebuilt, and they leaked badly; but they were repaired before the grinding began in 1904, and gave no more trouble.

The galvanized-iron pipe connections from the clarifiers to the settling and scum tanks leaked badly and gave a great deal of trouble. They should be replaced by standard galvanized-iron pipe. The float system, by which it was attempted to control the flow from the settling tanks last year, was abandoned with good results. This change made it possible to take off the butterfly valves and so reduce the work.

The scum is distributed to the scum tanks, shown in the upper left-hand corner of Pl. V, fig. 1, by means of a trough and runs out into another trough in the same way as the juice sent to the settling tanks. The scum tanks shown in position on the second floor plan (fig. 3), form three of the four compartments of a galvanized-iron vessel 4 by 10 by 3 feet, the fourth compartment being for the clean juice from the scum tanks which is drawn off after the scum has been blown up and

FRONT VIEW OF FACTORY.

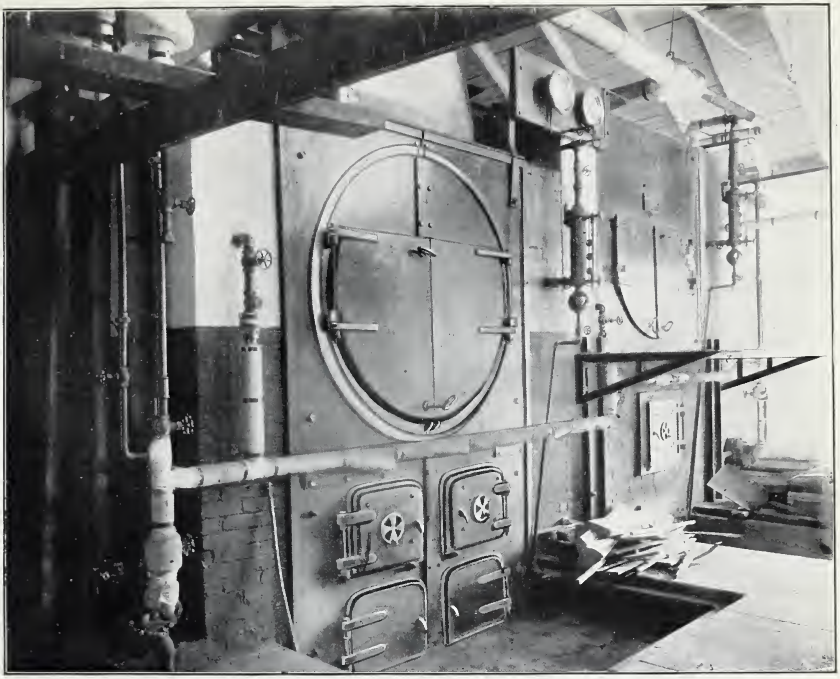


FIG. 1.—FRONT OF BOILERS, SHOWING FEED PUMPS, WATER CONNECTIONS, AND MAIN STEAM PIPE.

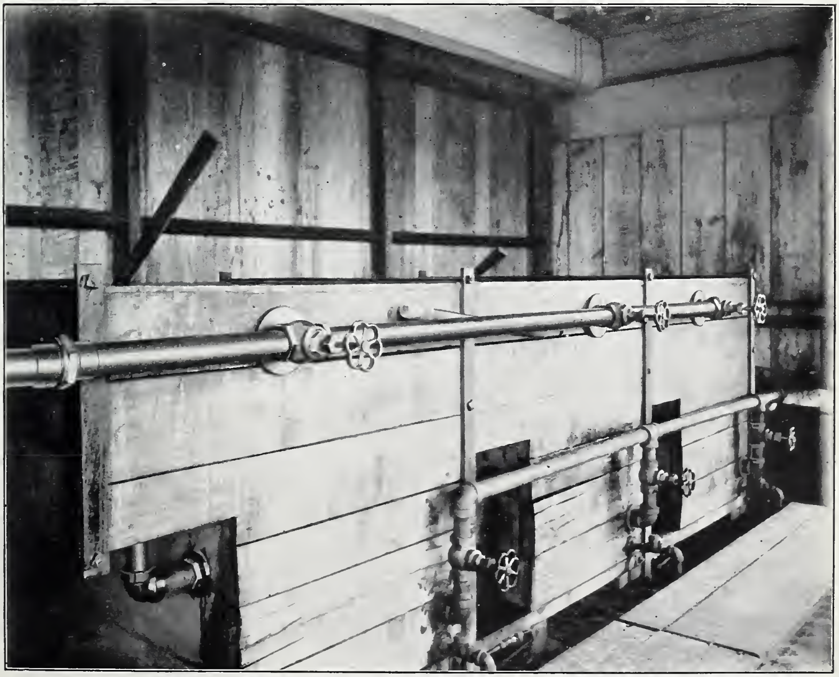


FIG. 2.—CLARIFIERS ON THIRD FLOOR.

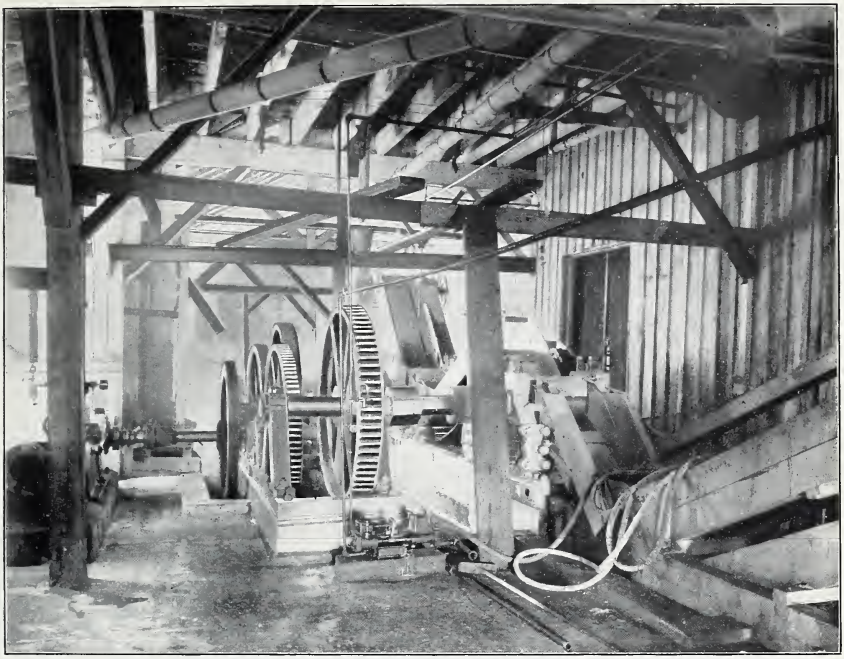


FIG. 1.—REAR END OF MILLS, SHOWING ENGINE, MILL GEARING, BAGASSE CARRIER, AND JUICE PUMP.

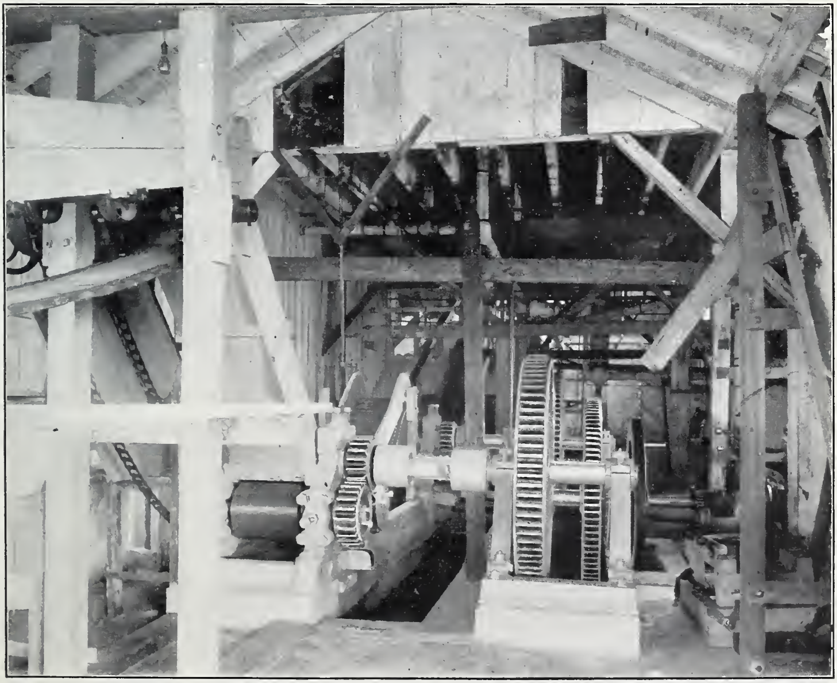


FIG. 2.—FRONT END OF MILLS, SHOWING CANE CARRIER AND CHUTE AND MILL GEARING.

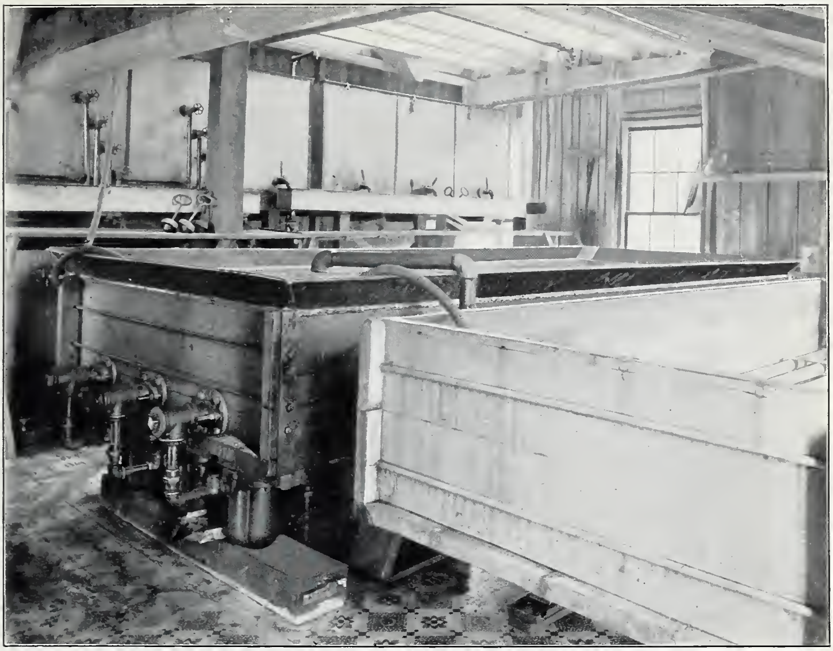


FIG. 1.—EVAPORATORS ON SECOND FLOOR; ALSO SHOWING JUICE AND SCUM TANKS AND HOOD.

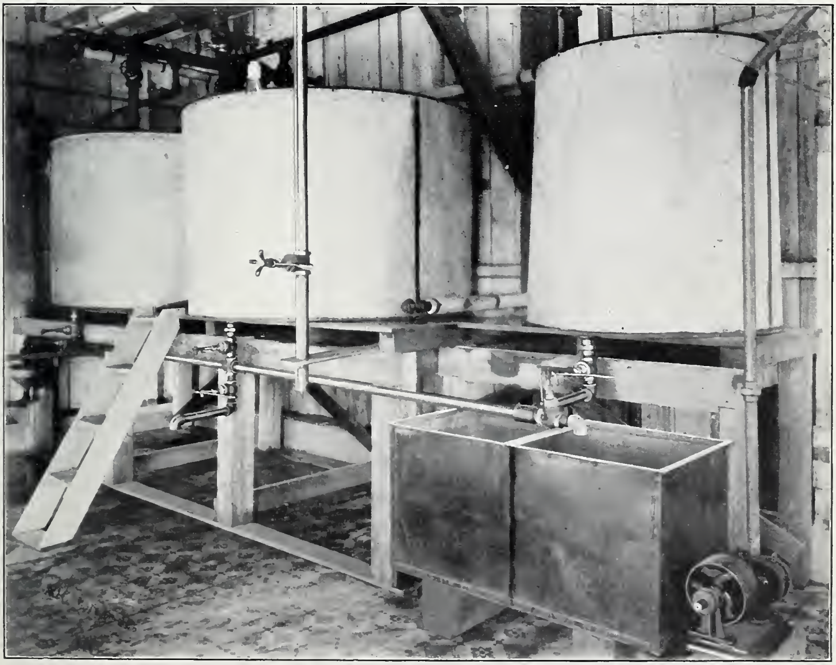


FIG. 2.—SIRUP STORAGE TANKS ON FIRST FLOOR; TWO OF 800 GALLONS EACH AND ONE OF 400 GALLONS CAPACITY.

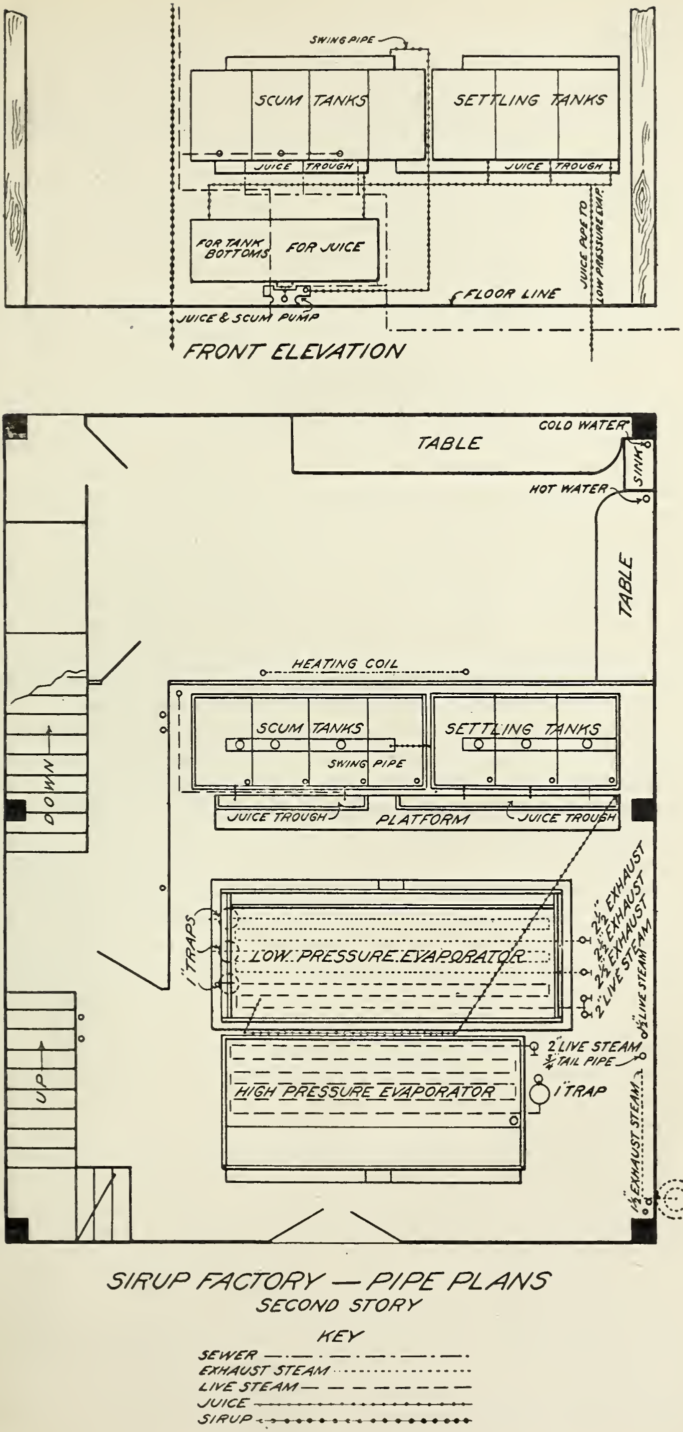


Fig. 3.—Second floor of factory.

allowed to settle. The outlets in the corners of the scum tanks lead directly to the sewer. There are four outlets in the front, the lowest one being in the right-hand corner, one and three-fourth inches from the side and bottom. The others are each 4 inches to the left, and 4 inches above the one below. Each outlet is fitted with an angle valve, and a piece of pipe extending just below the edge of the trough, the outlet from which leads to the second compartment of the juice tank.

Across the front of each tank and down the sides, runs a perforated steam pipe on the inside of the tank. When the scum has filled the tank to the level of the highest outlet the plug in the trough is shifted so as to fill another tank, and live steam is turned on through the perforated pipe until the mixture of scum, juice, and water boils. It is then left to settle for four to six hours, when it is drawn out through the lowest outlet, trying the higher outlets from time to time to see when the top layer of scum reaches them. When the clear juice begins to get muddy the outlet is closed, the rest of the scum is run into the sewer and the tank is cleaned.

The juice tank, shown in the second floor plan (fig. 3), into which the foots of the settling tanks and the clean juice from the scum tanks run, is a galvanized iron tank 2½ by 8 by 2½ feet. In 1904 it was raised to a foot from the floor, and its outlets were changed from gate to quick-opening valves. It is divided into two compartments, one for the foots, and one for clean juice. The steam pump, used last year for pumping juice, is connected with both compartments of this tank, with the scum tub of the low-pressure evaporator, and the scum tub of the finishing evaporator. The delivery pipe of the pump is fitted with a swing pipe so that it can deliver the foots and scum into the trough of the scum tanks, and the clean juices into the fourth compartment of the scum tank, which is fitted up like the settling tanks. The clean juice from this compartment is treated like the juice from the settling tanks. The pump system saved handling the scum from the evaporator and prevented the clogging of the jet pumps, which was a great source of annoyance last year.

The low-pressure evaporator, placed as indicated in the second-floor plan (fig. 3), which receives the juice from the settling tanks, was rebuilt during the summer, in order to correct some difficulties in working which appeared during the season of 1903. As rebuilt, the evaporator is of the same construction as the clarifiers, of 2-inch hard pine, lined with copper. It is 14 feet long inside, 4½ feet wide at the bottom, 5 feet 2 inches wide at the top, and 18 inches deep. Along both ends and the back side there was placed a flaring copper rim 6 inches wide, set at an angle of 45°, thus adding 4 inches to the width and height on the two ends and the back. On the front side the copper rim is vertical, 4 inches high, and forms the back of a scum trough 4 inches wide, 4 inches deep at the ends, and 6 inches deep in the middle, extending the whole length of the evaporator. From the lowest part of this trough a down spout extends just below the bottom of the evaporator, through which the skimmings are run into a tub connected with the small pump.

Inside the evaporator, on the front side, is another trough for automatically skimming the boiling juice. This trough is 8 inches wide, has a front 4 inches high, with a row of half-inch holes 3 inches apart and half an inch above the bottom of the trough. The trough itself is 8 inches above the bottom of the evaporator and extends the full length of it. The steam coils in this evaporator consist of three coils, each composed of three copper pipes 2½ inches outside diameter and 0.104 inch thickness of metal. On each end of each of these three coils is a cast brass sleeve, into which screws a brass nipple of 2½-inch iron-pipe size, 14 inches long, which passes out through a stuffing box in the end of the evaporator, there being three boxes in each end. On the left-hand end these nipples connect with the low-pressure steam pipe, which comes out of the top of a 12-inch pipe serving as steam receiver for the exhaust from all the engines and pumps in the plant, having a back-pressure valve which keeps the pressure in this receiver at 20 pounds. Each coil has its own connection with the main steam pipe, and, in addition, the first coil, which is the one next to the back of the evaporator, has a 2-inch connection with the live-steam pipe, with steam at 100 pounds pressure. The other ends of the coils connect with steam traps, there being one trap for each coil. As the traps were all the same size, the one on the first steam coil, which was used for live steam, was not large enough to carry off the condensed water and had to be kept almost wide open. A larger trap should be used on this coil.

Aside from a few minor defects, leaks, etc., the evaporator worked very well. It takes nearly two tanks of juice to cover the coils, and from three to four tanks for a complete charge. When running this evaporator, juice from two settling tanks is run in until the coils are covered, when the steam is turned on. A scum rises as the juice gets hot, and this is dipped off—the only skimming of this kind which is done. When the juice begins to boil vigorously the exhaust steam is shut off from the first coil and live steam turned on. Then a stream of juice from another tank is started, and the juice is run in just as fast as the evaporator will permit, till the density reaches 20° Baumé, when the semisirup is run down to the filters.

An attempt was made to run the evaporator with exhaust steam at the beginning of the season, but it was found impossible to keep up with the mills, when running intermittently, even at a slow pace. It was then attempted to run continuously. This made some improvement, but not enough to keep up with the mill, so live steam had to be used on the first coil throughout the season. It was found possible to run the low-pressure evaporator continuously, but not advisable to do so, except when hard pressed, since the sirup darkened to a considerable extent from the long contact with the hot pipes.

As the operator became more expert in running the evaporator he increased the speed and capacity remarkably and was at all times able to keep ahead of the mill, though by no large margin. The density of the juice made quite a difference in the length of time required for evaporation. On the poor green cane juice it was all that the evaporator could do to keep up, and sometimes the mills would have to stop, but on the juice that was fairly rich, toward the end of the run, the evaporator even had to wait for juice. With proper management this evaporator is large enough to handle the juice from the mill, but all cleaning must be done on Sundays, since it is impossible to do it while the mill is running.

The filters were rebuilt so as to make them stronger and to stop the leaks. These filters are of 2-inch cypress, and are 2 feet wide and 8 feet long at the top and 4 feet deep. Each filter contains 18 inches of sharp river sand, sifted first to take out all the pebbles, and then to remove all the fine sand that will pass a 24-mesh sieve. This sand is supported on a brass plate perforated by slits about one-fourth inch long and just wide enough so that the sand can not pass through. This plate in turn rests on a wire door mat, and this on a wooden slat frame 1 inch above the bottom of the filter. The semisirup from the low-pressure evaporator flows into the filter on top of the sand through a 1-inch pipe fitted with a float valve which closes when the filter is full.

The outlet of the filter is in the front of the bottom, where the filtered semisirup runs out through a valve into an open trough, with an outlet pipe leading to a small pump tank (Pl. V, fig. 2), whence the semisirup is pumped to the third floor into a 400-gallon storage tank, which holds it until it is wanted in the finishing evaporator on the second floor. Each filter holds 70 gallons of semisirup; it is customary to use two at a time, keeping one in reserve.

The semisirup contains so much sediment that it is usually necessary to wash the filters after each charge runs out. This is done by first running cold water in on top of the sand so as to displace any sirup remaining in it. When the density of the liquid running from the filter shows that the sirup is nearly all out, the cold water is shut off, the outlet valve of the filter is closed, and hot water is turned on through a pipe which leads down to the bottom of the sand, and terminates in a perforated pipe in the form of a cross, as long in each direction as the filter is wide. The hot water quickly fills the filter, bringing to the top all the sediment that has collected in the sand, and runs off through a washout pipe 2 inches from the top. When most of the light sediment is out, as is shown by the water becoming fairly clear, the hot water is shut off, and the filter emptied of water into a second trough parallel to the sirup trough, having an outlet into the sewer. After the water has run out there is always a considerable quantity of heavy mud left on top of the sand, though the sand below seems to be quite clean. This mud is scraped off with some of the sand and is burned on a plate of iron, heated from below, to recover the sand, which is saved to use again in the filters. This course is necessary, because the kind of sand used is quite expensive.

Just as good sirup can be made without filters as with them, but when using filters skilled labor is not necessary to skim the first evaporator, and the process can be very much hastened, since, instead of evaporating the juice slowly to boil out all the sediment, it is possible to push the evaporation to the limit, removing what scum arises and taking the remainder out in the filters. Five hundred gallons of juice have been evaporated to 200 gallons of semisirup in thirty-eight minutes, whereas an hour and a half would have been required if it had been skimmed clean while evaporating instead of having all the sediment taken out at once in the filters. The color of the sirup made is good evidence that this process does not darken the product.

The filtered semisirup runs into a pump tank (shown in the foreground of Pl. V, fig. 2), 2 by 4 by 2 feet, and is pumped from there by a rotary pump to a 400-gallon round tank on the third floor (fig. 4). The pump tank also has pipes leading into it from the round store tanks on the platform just above, and the pipe from the pump is so connected that it will deliver semisirup or the finished product into any of these tanks, instead of pumping it upstairs. The store tank on the third floor is elevated so that the semisirup can be delivered into an evaporator on the third floor, or to the finishing evaporator on the second floor.

The finishing evaporator is shown in figure 5 in detail as rebuilt. It is of 2-inch cypress, 12 feet long inside, 3½ feet wide on the bottom, 5 feet wide on top, and 18 inches deep in front, the ends and back being 2 inches higher. The front side rises at an angle of 45° from bottom to top. On the outside of the front is a trough 5 inches wide, extending the whole length of the evaporator. The bottom of this trough slants from the ends to the middle, where there is a down spout emptying into a tub. This evaporator has a single coil of six pieces of 2-inch galvanized iron pipe, 11 feet 6 inches long. The outer lengths are extended by lock-nut nipples through one end of the evaporator, the one on the back connecting with the steam pipe, and the one on the front with a trap for passing off the water without loss of steam. In case of emergency there is a 2-inch pipe fitted with a quick-opening valve between the evaporator and the trap, so that the steam in the coil can be blown out instantly to check the boiling. The outlet of this evaporator is in the corner under the outlet of the steam pipe, and is closed with a quick-opening valve. The evaporator has the back side and the end away from the steam entrance raised so as to drain the sirup to the outlet.

This evaporator is usually operated by filling it about half full of the semisirup, cooking slowly to about 25°, and then rapidly to 35°, the theory being that the bulk of the scum comes out before the sirup passes 25°, and that after that density has been reached the faster the sirup is cooked the better. Toward the last of the season, Mr. Geo. R. Youmans discovered that the scum which came off before 25° was reached was only a small part of what might be boiled out, and that the proper way to evaporate the sirup was to boil it rapidly till a density of about 27° was reached, and then just as slowly as possible till the sirup was finished. The process thus conducted is as follows:

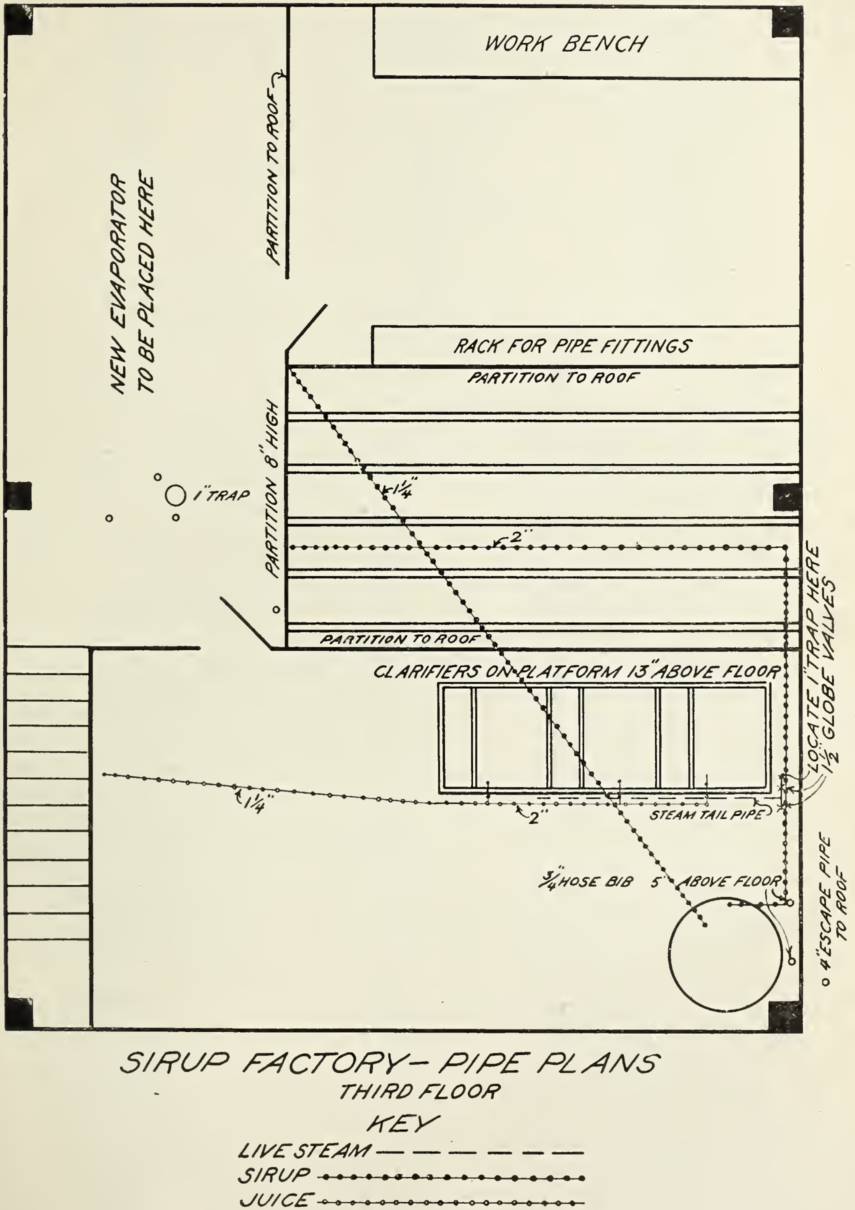


Fig. 4.—Third floor of factory.

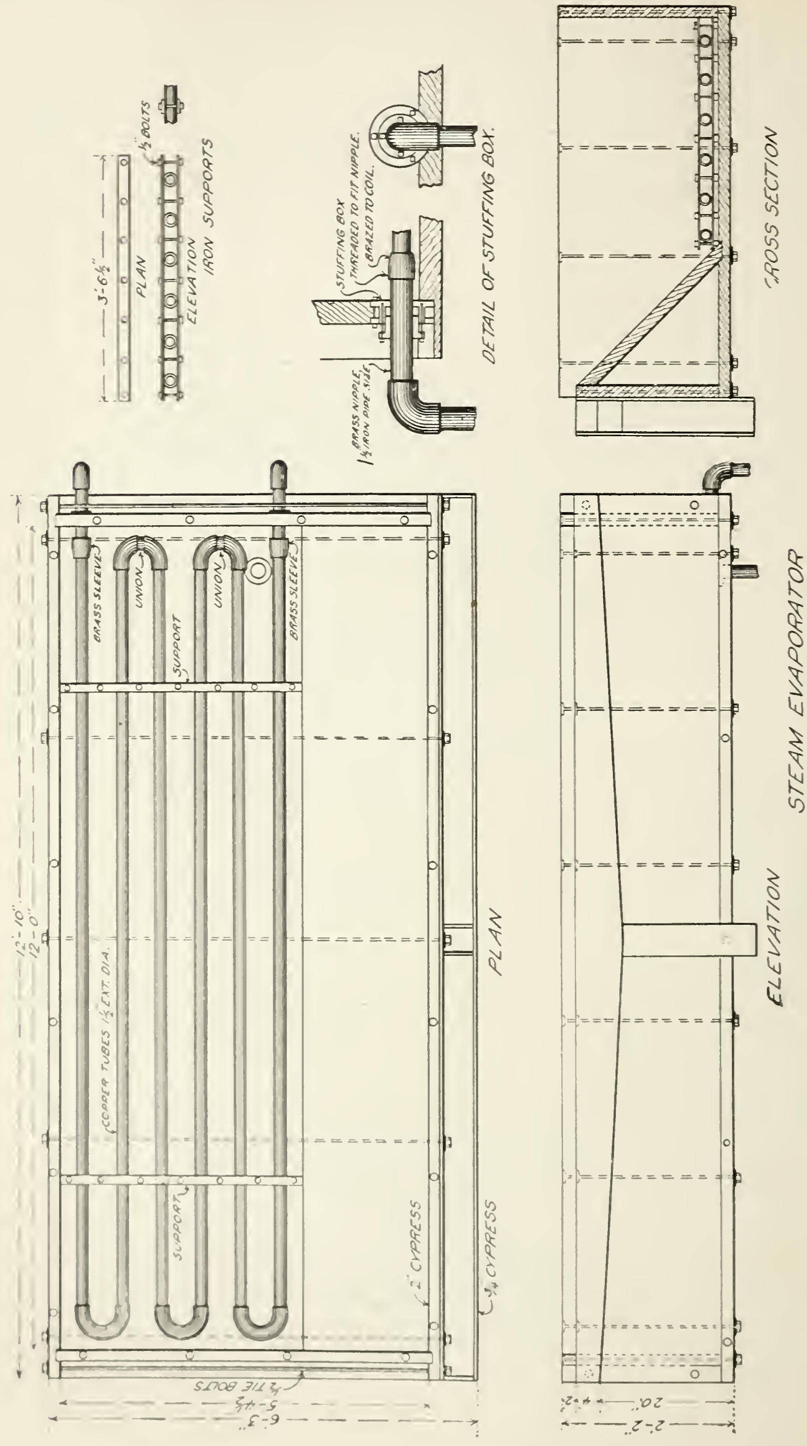


FIG. 5.—Working drawing of finishing evaporator.

Run semisirup into the evaporator till the coils are just covered and turn on the steam, slowly at first, so as to get off the blanket which forms; then turn on full steam till the semisirup boils, at which point open the inlet valve as far as the amount of sirup in the evaporator will permit. Keep the semisirup running in until the density of the sirup reaches 26° or 28°; then shut off the steam except just enough to make the sirup boil, so as to carry the scum to the front of the evaporator. From this time till the sirup is done, at 35° Baumé, the scum will form as fast as two men can remove it, and if they skim it fast enough to get the sirup clean by the time it is sufficiently evaporated the product will be absolutely clear and bright, with not a trace of muddiness or cloudiness, though probably one or two shades darker than when cooked in the other way.

The long slanting side of the evaporator makes it possible to use a peculiar kind of skimmer, which is much more rapid than the usual dipper form. This is a piece of cypress board 1 inch thick, 4 inches wide, and 18 inches long, beveled on both edges, and having a straight handle about 16 or 18 inches long set in the middle of the broad side. These skimmers enable one to draw the scum up the inclined side and into the trough very quickly and easily and with less loss of sirup than any other form. Moreover, since they are so short-handled, three men can skim at once if necessary.

When the spindle shows that the sirup is finished the steam is all shut off, the last coating of scum and foam is removed, and the sirup is run into one of the storage tanks (fig. 1, also Pl. V, fig. 2) on the platform on the first floor. From these tanks it is drawn either into barrels or into measures, from which it is poured into cans or bottles. These tanks are provided with an outlet for barreling and canning, an outlet into the pump tank, and another into the sewer.

Results of the Season's Work.

MILLING.

Experience has shown that 65 per cent of the juice is about all that can be commercially extracted from cane with one mill. With two mills 75 per cent can be obtained while grinding to the full capacity of the mill. The first mill extracts from 55 per cent to 65 per cent, according to the feed, and the second mill increases this percentage to about 75. An extraction of 65 per cent, as compared with an extraction of 75 per cent, means a loss of very nearly one-sixth of the juice and therefore of one-sixth of the sirup. That is to say, if 20 gallons of sirup can be made from a ton of cane using one mill, 24 gallons can be made by using two mills; or in a plant making 500 gallons a day there is a saving of 75 gallons of sirup. On the other hand, the juice from the second mill is not quite so pure as that from the first mill, making it more difficult to clarify. A comparison of the juice from the green cane and from the first and second mills is given in the following table:

Table XIV.—*Analyses of cane juices from factory at Waycross, Ga., comparing products from first and second mills.*

Serial number.	Date.	Density.	Sucrose.	Reducing sugar.	Purity.	Description.
		° *Brix.*	*Per cent.*	*Per cent.*		
3436	Dec. 5, 1904	14.00	8.33	5.57	59.50	Green-cane juice.
3438	Dec. 6, 1904	18.00	15.54	.98	86.10	Juice from first mill.
3439	.....do.......	16.40	12.13	1.55	73.80	Juice from second mill.

The work at Waycross has shown that by this process the whole body of sirup is darker by about two degrees on the sirup color scale.[a] This is not of much importance, however, when it is considered that the darkest sirup made this year was 14, and that from cane which had begun to sprout. Eight thousand gallons of sirup between 10 and 12 in color were made, which is quite as light as the average of first-class sirup on the market.

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[a] See page 65.

FUEL.

The bagasse burner did not have a fair test, as the plant was not run the full 24 hours. It is, however, possible to make a comparison with another plant which did run the full time, and so had a great advantage over the Waycross plant in the matter of fuel saving. At Waycross there was burned, in making 11,000 gallons of sirup, running 10 hours a day, 100 cords of wood in addition to the bagasse. Two-thirds of this wood was burned in the forenoon in getting the burner hot enough to burn the bagasse to advantage. Another plant burned 300 cords of wood in making 22,000 gallons of sirup, running 24 hours a day, and had in addition the cost of hauling the bagasse away, which took all the time of a man and team.

It is evident that the Waycross plant has the advantage, on the same quantity of sirup, of 50 cords of wood, besides saving the cost of hauling away the bagasse, and this in a case where the wood-burning plant had all the advantage gained by a 24-hour run as compared with a 10-hour run. Another point in favor of the use of a second mill is that it leaves the bagasse dry enough to burn readily.

CLARIFICATION.

The clarifiers accomplish just what is done in the ordinary kettle or evaporator—take off the blanket scum; but they take it off very much quicker than the evaporator does. The juice is not left as clean as it is in an evaporator after boiling for half an hour and being skimmed all the time, but the largest amount of scum is removed in the shortest possible time. Also, in common with the settling tanks, the clarifiers provide storeroom for the juice in case the evaporator gets behind, so that the mill does not have to stop as soon as the evaporator is full.

The large low-pressure evaporator does not leave the semisirup as clean at the same stage of evaporation as would a single evaporator of the usual type, but it boils a great deal more juice down to semisirup in the same time even if the evaporators are of the same size, which is not common, the low-pressure type being usually larger. This result is due partly to the 100 square feet of heating surface which it has and partly to the use of the coil full of live steam, which boils the juice so hard that a full charge—500 gallons—of juice has been evaporated to 200 gallons of semisirup in 38 minutes.

This evaporator skims itself very successfully into the trough provided, but even so, the cooking is so rapid that not half of the scum which is formed comes off. All the sediment, which is so apparent in a sample of semisirup from the evaporator, is taken out by the filters, which leave the semisirup even cleaner than it would be ordinarily. Therein lies the advantage of the combination; the clarifiers, settling tanks, and big evaporator provide a means of producing semisirup at a very much faster rate than is usual, and, by the employment of another man to run the filters, it is possible to make this semisirup even better than the ordinary semisirup in point of of brightness. It is not that this method makes better sirup than the other, but that it makes it so much faster. It is possible for this plant to handle 3 tons of cane an hour, getting the maximum quantity of sirup from it, and sirup of the best quality, so that if run for the full 24 hours the plant will turn out 1,500 gallons of sirup a day. To do this requires two crews, each made up of 16 men and boys, divided as follows: One engineer, one fireman, one man at carrier clutch, three men feeding carrier, one clarifier man, one man to run settling tanks, scum tanks, and low-pressure evaporator (with one helper), one filter man, one packer (with two helpers), and one general helper. In addition, there should be a foreman of the crew.

It takes about five hours from the time grinding begins to run off the first charge of sirup. There is very little waiting, and the juice is practically in continuous motion. With the mill running up to its capacity, it takes seventy-five minutes to grind a charge for the big evaporator, but it is an hour and a half longer before the juice gets into the evaporator. An hour more suffices to complete the evaporation to semisirup and the filtration, and about three-quarters of an hour to get it into the finishing evaporator. About half an hour is all that is necessary to boil the sirup down to 26° or 28° Baumé, including the time of heating to boiling and the skimming off of the first blanket. From 28° to 35° is the crucial time of the process, for the care with which it is skimmed determines the final appearance of the sirup. At the very slow rate of evaporation employed to give time for a thorough cleaning, it takes very nearly forty-five minutes to finish the sirup; ten minutes more is required to run off the charge into the storage tank for barreling or canning.

In making sirup for the market two things must be especially considered: (1) To make a sirup that will keep, i. e., not ferment, and (2) to make a sirup that will not deposit a quantity of sugar crystals in the bottom of the package when kept in storage for a month or two. It has long been known that sirup evaporated to a greater density than usual will keep, but it almost invariably crystallizes badly. And further it is known that recooking the sirup with a certain amount of glucose makes it heavy enough to keep without fermenting and at the same time prevents crystallization. The object of our experimental work was to accomplish the same result without using glucose. It was evident at the close of the season of 1902 that the problem was almost solved. The later work seems to show that the use of the separate clarifier, the settling of the sediment, which allows the juice to cool somewhat, and reheating in the evaporator—especially when slowly boiled, as in the process described—brings about more inversion than would otherwise take place and prevents crystallization in a sirup of this density.

Of course, if the sirup were boiled to 37° or 38° Baumé, it would require more inversion, but as the sirup will keep well if boiled to 35° hot, there is no object in carrying the evaporation further. In view of the results obtained toward the last of the season in improving the brightness and keeping quality of the sirup, it may be considered that a considerable advance has been made toward a more definite knowledge of the principles of the subject.

SUMMARY OF THE WORK DONE.

Grinding began November 3, and was finished December 9; time covered, 37 days, less 5 Sundays, 1 holiday, and 3 days lost for lack of cane, leaving 28 days on which grinding was done, though the plant was in operation one day more.

The following table shows the amount and character of the juice and the quantity of sirup produced daily.

TABLE XV.—*Amount of juice and sirup produced during the season of 1904 at Waycross, Ga.*

Date.	Tanks of juice.	Density.	Sirup finished.	Date.	Tanks of juice.	Density.	Sirup finished.
1904.		° *Brix.*	*Gallons.*	1904.		° *Brix.*	*Gallons.*
November 3	10	14.5	50	November 22	19	16.1	436
November 4	14	14.5	240	November 23	0	0.0	282
November 5	16	14.6	400	November 25	21	16.5	238
November 7	18	15.1	400	November 26	20	16.8	510
November 8	19	14.8	400	November 28	10½	17.1	580
November 9	17	14.2	400	November 29	22	17.0	540
November 10	20	15.3	400	November 30	9	16.7	482
November 11	15	13.4	580	December 2	17	15.9	318
November 12	15	14.0	450	December 3	13	14.7	280
November 14	17	16.1	480	December 5	20	14.7	470
November 15	8	17.1	343	December 6	15	16.8	480
November 16	21	14.0	300	December 8	18	15.6	256
November 17	23	16.1	500	December 9	5		
November 18	21	13.9	461				
November 19	14	15.8	346				
November 21	23	14.7	406	Totals and averages	460½	15.4	11,344

Thus in twenty-eight days 575.1 tons of cane were ground, yielding 460.5 clarifier tanks of juice of 185 gallons each—representing almost exactly 1¼ tons of cane, or very nearly 20.6 tons per day. This total of 460.5 tanks, or 85,192.5 gallons, of juice produced a total of 11,344 gallons of sirup, 7.5 gallons of juice being required for 1 gallon of sirup. An average of 19.7 gallons of sirup was obtained per ton of cane, which is very good for an average density of only 15.4° Brix.

Toward the last of the season a careful record was kept of an exceptionally fine lot of cane which was run by itself. This record is as follows:

TABLE XVI.—*Record for special lot of cane.*

Date.	Tanks.	Density.	Sirup.
1904.		° *Brix.*	*Gallons.*
November 25	21	16.5	238
November 26	20	16.8	510
November 28	10½	17.1	580
November 29	22	17.0	540
November 30	....	....	323
Totals and averages	73½	16.8	2,191

On this run in four days 91.9 tons of cane were ground, or 23 tons per day, and 2,191 gallons of sirup made, or an average per ton of 23.8 gallons; and of the 13,597.5 gallons of juice expressed, 6.1 were required for each gallon of sirup. If more of the cane had been of this quality, the total yield of sirup would have been much greater and the quantity of wood burned much less.

SUGGESTED CHANGES AND IMPROVEMENTS IN PLANT.

A summary of the improvements, which the work of the past season has shown would add a great deal to the efficiency of the plant, is given below. The estimates are based on the cost of work done during the past season, and are liberal.

1. An additional high-pressure evaporator like the one now in use, except that it should have copper coils and stuffing boxes. Estimated cost, $150.

2. Copper coils for the high-pressure evaporator now in use, with stuffing boxes like those on low-pressure evaporator. Estimated cost of change, $60.

3. A large steam trap is necessary for each of the high-pressure evaporators and for the live-steam coil of the low-pressure evaporator. Those at present in use do not carry off the condensed water fast enough. Estimated cost of change, $75.

4. Two of the present traps, when thrown out by the above substitution, should be used on the clarifiers, giving each clarifier its own trap. Estimated cost of change, including piping and by-passes on all traps, $25.

5. The sirup storage tanks should be raised 1 foot and inclined to the front, so as to drain better. Estimated cost of change, $10.

6. The present sewer pipe should be relaid, using 6-inch pipe from the junction of the two 4-inch lines to the street sewer. Estimated cost of change, $100.

7. The fire-brick lining of the fire box of the old boiler, in front over the door frames, must be taken out, relaid, and well secured, so as to be permanent. Estimated cost, $5.

8. A centrifugal oiler should be applied to the engine crank, as the crank frequently heats with the present oil cup. Estimated cost, $5.

9. A hood should be built over the feed-water tank and an opening made in the side of the building to permit the escape of the steam from the heated water, so that it will not rise in the mill shed and keep the shafting and pulleys rusty and the belts slippery. Estimated cost, $10.

10. The light, galvanized-iron pipes leading from the clarifiers to the settling and scum tanks should be replaced by 3-inch standard galvanized-iron pipes. Estimated cost, $35.

11. There are two leaks in the low-pressure steam coils of the low-pressure evaporator which must be stopped. Estimated cost, $2.

12. There is a leak in the lining of the same evaporator which must be stopped. Estimated cost, $3.

13. An awning crank, ratchet, and hangers should be obtained for raising the roof of the ventilator, as it is so heavy that it is very difficult to raise it at present. Estimated cost, $5.

14. It is recommended that a small direct connected engine and dynamo be installed to furnish the lights for the plant. Estimated cost, $300.

15. The mechanical strainer, materials for which are already on hand, should be put in and connected with both rotary and steam pumps. Estimated cost, $25.

16. The take-up at the bottom of the bagasse carrier should be changed to the top of the carrier, thus making it much easier of access, and leaving enough room at the bottom of the carrier to clean out the pit better. Estimated cost, $10.

17. The engines and pumps must be cleaned and put in order to begin work. Estimated cost, $100.

Total estimated cost for putting the factory in perfect repair for the season, $1,000.

INSPECTION OF OTHER PLANTS.

Toward the last of the season, when the supply of cane was running short, so that the factory could not run continuously, an opportunity was afforded to visit other plants. The first to be visited was a small plant at Manor, 14 miles from Waycross. This plant was put up in the fall of 1904, and has a 16-inch mill driven by an old 25-horsepower boiler and engine. As the mill is set very close to the ground the juice runs into a round tank of about 500 gallons capacity, sunk in the ground. It was intended to use a steam pump to raise the juice to a tank in the top of the shed; but at the time the plant was visited the juice was carried from the juice tank to the evaporators in pails; one man doing the work besides firing the evaporators. There were two evaporators of the continuous type, set on brick furnaces, and using wood for fuel. The finished sirup from both evaporators runs into a 500-gallon tank sunk in the ground about half its depth, and is dipped from there by hand to be barreled or canned.

The plant at the time it was inspected was making a very pretty sirup, but, on standing, it deposited a large amount of flocculent precipitate. The superintendent stated that they were making 350 gallons per day of eleven hours, but as the capacity of the mill is only 1½ tons per hour this seems hardly possible. The mill is speeded up to 25 revolutions per minute and shoots the cane through very fast, but the man who feeds it only puts in three or four canes at a time, and, as the mill chokes every little while and there is trouble very often with the water supply for the boiler, the mill will hardly grind up to its rated capacity, even though it is run so fast. The high speed cuts the bagasse quite fine, but as such a light feed is used the bagasse rollers can not be set close on account of the choking of the mill and the extraction is consequently very poor.

On December 9, the factory on the plantation of Messrs. West, Holmes, and Coffee, at Lake Park was visited at the request of the owners. This plant has a 24-inch mill driven by a 100-horsepower high-speed engine which also runs a ginhouse and gristmill. The plant is built on the side of a hill, and is the best-arranged small factory visited. The mill stands on a platform about 8 feet above the ground, on the downhill side of a large open shed into which the cane is unloaded from the carts by hand and piled close to the mill. The juice from the mill runs into a round wooden tank of about 1,000 gallons capacity. From this tank it is conducted into either of two steam evaporators placed close to it and just low enough for the juice to run into them. Here it is heated, skimmed, and partly concentrated, then run into another similar evaporator just below, to be finished. The finished sirup runs into a round 500-gallon tank, and is drawn from that into barrels.

There is no pumping at all, and if the construction of the evaporators and the arrangement of the piping had been good, it would have been almost an ideal plant of its kind. These were so poorly constructed, however, that the owners could not get satisfactory results, and, hearing that the Waycross plant was doing good work, the assistance of the Department agent was requested. It needed only a casual inspection to disclose the trouble. None of the tanks or evaporators was provided with wash outs, and the only way of cleansing a tank was to let the wash water run into the next one, and so on to the bottom, or to mop it up. The steam pipes instead of passing through the ends or sides of the evaporators, were led straight down through the sirup, and of course scorched it at the surface all the time it was evaporating.

The three evaporators were made of pine, with galvanized-iron lining, and provided with a steam coil of nine lengths of 1¼-inch galvanized-iron pipe. The tail pipes passed up through the sirup just as the steam pipes passed down. No traps were used, the passage of the steam through the coils being regulated by a valve on the tail pipe, making it necessary to manipulate both steam and tail-pipe valves to get any results. The boiler being 50 feet from the evaporators, the steam was brought to the evaporators through a 2-inch pipe which had, of course, less area than the three 1¼-inch pipes of the three evaporators, to say nothing of the condensation in 50 feet of uncovered pipe. To make matters worse, the outlet from the dome of the boiler was only 1½ inches, and the steam had to pass through a 1½-inch globe valve. Even with 100 pounds steam pressure it was only possible to get the three evaporators to boil very slowly at the same time.

At the request of the owners, a list was made of all the pipes and fittings required, the following changes being made: The 2-inch steam pipe was replaced by a 3-inch pipe and this was covered. This pipe was carried, full size, to where the second evaporator connected with it, and from there to the third evaporator as a 2-inch pipe. The finishing evaporator steam coil was made into two, with two steam inlets, controlled by the same valve. A steam trap was placed on the tail pipe of each evaporator so as to do away with the use of the tail-pipe valves and to economize steam. The outlets of these three traps were piped together, and the water led to a well where it could be used to feed the boiler again. The juice tank and three evaporators were supplied with wash outs, all the washout pipes being connected and the outlet run off under ground.

The sirup produced during the subsequent run had an average color of about 12. It was made by the system of evaporating developed toward the last of the season at Waycross and was a very good article. This is a little remarkable, as the cane was all cut before December 5, and, when hauled to the mill showed the red butt ends characteristic of cane long cut, which usually produces a dark sirup. The evaporators were very unsatisfactory. Instead of a slanting side running to the bottom of the evaporator, the skimming side slanted for about 6 inches of the depth and then went straight down. This made it necessary to dip off the scum after the semisirup or sirup got below the edge of the slant, and as it was impossible to fill the evaporator above this point, it was necessary to dip most of the time. This was slow work, and the scum could not be removed as completely as by scraping it off, as was done at Waycross.

On December 13 a large plant at Thomasville was visited. This plant was put up by Chicago capitalists. The plant has a 48-inch mill with 6 rolls controlled by hydraulics. The mill has a 60-foot cane carrier and a short bagasse carrier which drops the bagasse onto a carrier traveling at right angles that conveys the bagasse to the boilers. The plant has three boilers aggregating 270 horsepower, and the Dutch-oven style of bagasse burner is used. Neither the exhaust from the mill engine nor that from the various pumps is used at all. Under these conditions the bagasse furnishes only about half the fuel, and the burners do not work well.

The mill has a rated capacity of 12 tons per hour, but was grinding only from 7 to 8 tons per hour, and a great deal of trouble was caused by choking. From the appearance of the bagasse the extraction was estimated to be about 68 or 70 per cent. The mill is not fitted with a mechanical strainer, and the juice is only strained through a coarse wire screen. It is pumped from this strainer to the clarifiers on the fourth floor of the building, of which there are four of 1,400 gallons capacity each. The juice comes down into the clarifiers through a large upright pipe, meeting an upward current of sulphurous acid from a burner such as is used in Louisiana for mills grinding 25 tons per hour. To each clarifier of juice 4 gallons of milk of lime of 15° Baumé is added. The clarifiers are heated by a coil of twelve 3-inch copper pipes, having one steam inlet in the middle of the coil, and an outlet connecting with the trap on each side. A very satisfactory clarification is secured.

The clarified juice goes to the floor below where there are eight galvanized iron rectangular settling tanks of simple construction connected by a common pipe with a cotton strainer. These tanks have a capacity of 750 gallons each. The scums from the clarifiers and the footings from the settling tanks are run into a mud tank and pumped from there into a filter press, the liquid from which goes to the evaporators with the other juice.

Six continuous evaporators like the one at Waycross are used. Each evaporator has a man to run it. The sirup has the greenish-yellow color of sorghum, but is much lighter. It should be understood that the evaporators are not on the second floor proper, but on a projection from a higher part of the building. This extension is open on three sides, the side of the building forming the only closed side, thus allowing the steam to escape freely. The closed part of the second floor is used for storage. The whole of the first floor is used for packing and storing the sirup, half the floor being open like the evaporator room. The sirup from all the evaporators flows into a tank just under the second floor, and is drawn from that into the various packages.

As the sirup comes from the evaporators it varies in density from 30° to 35° Baumé, and really needs to be mixed before being packed. The lime used in clarification coats the coils of the evaporators very quickly, so that they must be cleaned every five hours, which is done by scraping them. Two men are kept busy at this all the time, and extra sets of coils are provided so as not to have the evaporators idle. These evaporators are not very satisfactory and it is proposed to put in a new vacuum pan next year. Otherwise, the plant is fairly satisfactory to the owners.

The next plant visited was that of Mr. W. B. Roddenbery at Cairo. The new method of evaporation previously described was explained and tried with equally as good results as had been obtained at Waycross.

The procedure at Mr. Roddenbery's plant is exactly the same as that at Lake Park, but the mill, evaporators, etc., are very much better. The mill is placed at the ground level, and the juice runs into a tank set in a pit. From this tank it is pumped into the first two evaporators as wanted. The cane is ground on a 24-inch mill which does very good work. There is no cane carrier, but the chute of the mill is extended with boards to a length of about 10 feet. A track of I beam is raised 15 feet in the air on strong trestles, and on this track is a traveling triplex pulley. The cane is loaded in tightly tied slings on the wagons which are driven under the block, the hook is fastened into the slings, and two men raise the whole load at once, either placing it on the feed table, or back under the track for later use. This is not a very rapid way of handling the cane, but it calls for fewer men, especially as the mill grinds much faster than the juice can be evaporated.

The mill grinds between 2 and 2½ tons per hour, and gives about 65 per cent extraction. It is rated at 3 tons per hour, and will grind this amount if properly fed. Mr. Roddenbery estimates that 1,000 tons of cane were ground in 1904. To do this work 300 cords of wood were burned, and, as the fuel question is becoming a serious matter, the installation of a bagasse burner before the next season is being considered. Further, the 80-horsepower boiler at the plant has to be forced all the time to obtain sufficient steam.

The plants at Cairo and Lake Park differ in the treatment of the scums. At Lake Park the skimmings from the first two evaporators are fed to hogs, while those from the finishing evaporator are reboiled in an iron kettle, and made into sirup for the use of the laborers on the place. At Cairo all the skimmings go to a tank, fitted with steam pipes, in the basement, and when the tank is full the contents are heated and skimmed until the juice is clean, when it is pumped up into settling tanks and evaporated with the fresh juice, as is done at Waycross.

Mr. Roddenbery has another plant at Grand Ridge, Fla., which is a duplicate, as far as apparatus is concerned, of the Cairo plant, but much better arranged. It is lighted by electricity, the installation costing only $90. The plant complete cost $5,000.

The plant of Mr. J. T. Wells, at Guyton, was next visited. This plant had shut down for the season, but as it is in many respects second only to the plant at Waycross in completeness, it is worthy of description. Mr. Wells has the clarifiers, settling tanks, and scum tanks which the Department used in the experiments at Guyton in 1902–3, but they are much better arranged than before. This plant has a 24-inch mill, the cane being unloaded by hand onto a large platform beside the mill, and carried to the chute by two or more laborers, one man feeding the mill. It has a maximum capacity of 2½ tons per hour, and will give from 60 to 65 per cent extraction without choking.

The juice runs back under the mill through two strainers and into a tank of 400 gallons capacity, from which it is pumped by a rotary pump to the clarifiers. These are placed 12 feet above the ground. There are 4 clarifiers, in pairs side by side, with a passage between them. From the clarifiers the clean juice runs to the settling tanks and the scum to the scum tanks, where it is treated as at Waycross. The settled juice runs from the settling tanks into either of two similar evaporators, one of which furnished the original model for the high-pressure evaporator at Waycross. The sirup is concentrated in these evaporators, no finishing evaporator being used. This system of evaporation requires about three hours for a charge, which makes about 60 gallons of sirup. The plant has a maximum capacity of 400 gallons per day of twelve hours, but the usual quantity made, because of lack of steam capacity, is about 250 gallons. Approximately 4,000 gallons were made this year, but less will be made next year because of the low price of sirup in the local market.

Both Mr. Roddenbery and Mr. Wells make the same grade of sirup as was made at Waycross previous to the perfection of the new method of finishing the product. The sirup made at Cairo in 1904 was an improvement on that of the previous year, though not so good as that of 1902

CHEMICAL DATA.

DIRECTIONS FOR SAMPLING AND PRESERVING JUICES FOR ANALYSIS.

The following are the directions for taking, preserving, and forwarding samples of the juice and sirup produced:

Two small samples of juice (50 or 100 cc) should be taken from each tank filled during the day and placed in two large glass jars. To one of these should be added as much mercuric chlorid (corrosive sublimate) as can be held on a quarter of an inch of the point of a knife blade. To the other should be added 10 cc of the lead subacetate solution for each 100 cc of juice placed in the jar. After each addition of juice the contents of the jar must be well mixed.

At the end of the day's run, the temperature of the juice in the jar containing the mercuric chlorid should be taken with the centigrade thermometer and the density with the Brix spindle; these readings, together with the total quantity of juice produced, the total volume of the leaded sample, and the total quantity of subacetate used, should be recorded on one of the juice labels pasted on a sample bottle, which should then be filled with the well mixed leaded sample, tightly stoppered (the stopper being tied in), placed in a mailing case, with sufficient cotton to prevent breakage, and mailed to the Bureau of Chemistry.

A sirup sample bottle should likewise be filled with a representative sample of the day's run of sirup and packed and mailed in the same manner.

In preserving the juice samples for 1904 it was suggested by Dr. G. L. Spencer that formaldehyde be used instead of the mercuric chlorid in the density sample, because of the fact that such a very small quantity of formaldehyde was required that it produced no variation in density. Three-tenths cubic centimeter of 40 per cent formaldehyde was used per liter of juice. Dr. Spencer also suggested the use of dry lead subacetate instead of the solution of lead subacetate for the juice sample for analysis, since samples thus preserved had been found to keep equally as well as those where the solution was used and the dry substance is much more convenient, since no material correction is to be made for the volume of the subacetate solution added. Three grams of the dry subacetate were used for 100 cc of juice.

METHODS FOR SIRUP EXAMINATION.

1. *Color.*—Fill one of the extra vials supplied with the standard colors with the sirup to be examined, and find by comparison with the standards which color most nearly matches that of the sirup. Denote the color by the number stamped on the top of the color standard vial.

2. *Density.*—Dilute 20 grams of the sirup to 100 cc, determine the degree Brix of the dilute solution, correct for temperature, and read the density of the original sirup from the table given on page 64 (specific gravity multiplied by the degrees Brix divided by the weight taken).

Table for the estimation of the approximate per cent total solids in massecuite, molasses, etc.[a]

(Dilution of sample—100 grams to 500 cc.)

Degrees Brix of diluted sample (corrected for temperature).	Per cent solids in original sample.	Degrees Brix of diluted sample (corrected for temperature).	Per cent solids in original sample.
14.0	73.99	16.0	85.25
.1	74.55	.1	85.82
.2	75.11	.2	86.39
.3	75.65	.3	86.96
.4	76.22	.4	87.53
.5	76.79	.5	88.10
.6	77.35	.6	88.67
.7	77.91	.7	89.24
.8	78.47	.8	89.81
.9	79.04	.9	90.38
15.0	79.60	17.0	90.95
.1	80.16	.1	91.52
.2	80.72	.2	92.10
.3	81.29	.3	92.67
.4	81.86	.4	93.22
.5	82.42	.5	93.82
.6	82.99	.6	94.39
.7	83.55	.7	94.97
.8	84.12	.8	95.54
.9	84.68	.9	96.12

[a] G. L. Spencer: A Handbook for Beet-sugar Chemists, p. 291, Table 261.

3. *Sucrose.*—Weigh out 26 grams of sirup, wash into a 100-cc flask with hot water, add 5 to 10 cc of lead acetate solution, cool, make up to volume, filter, and polarize. Precipitate the lead from the above solution with sodium carbonate, filter, place 25 cc of the filtered solution in a 50-cc flask, acidify with acetic acid, and add 5 cc of concentrated hydrochloric acid. Let stand over night. In the morning make up to volume and polarize. The temperature should be nearly the same at the two polarizations and should be carefully noted. Calculate the sucrose by the formula

$$\frac{100\,S}{142.66-\frac{t}{2}},$$

in which S equals the algebraic difference between the two polarizations, and t is the observed temperature.

4. *Reducing sugar.*—Dilute 25 cc of the lead-free solution (described above) to 200 cc and determine the reducing sugar with Violette's solution.

5. *Purity.*—Divide the per cent of total sugar by the total solids (density, degrees Brix).

6. *Ash.*—Weigh about 10 grams accurately in a large platinum dish, add a few drops (1 or 2 cc) of concentrated sulphuric acid, and heat with great care until all is charred. Burn down in a muffle at low red heat, extract with hot water, and finish burning over a blast lamp. Add the water extract, evaporate to dryness, ignite gently, and weigh. Deduct one-tenth from the weight of the ash for the sulphates formed and calculate the remainder as ash.

7. *Moisture.*—Place 5 to 10 grams of clean white sand in a platinum dish of convenient size, ignite, cool, and weigh. Add about 1 gram of sirup and weigh carefully. Add water enough to moisten sand and mix thoroughly. Dry to constant weight in a water oven and calculate loss as moisture.

THE COLOR STANDARD.

The materials used in preparing the standard color solutions are (1) pure glycerin, and (2) a caramel solution, which is prepared as follows:

Six grams of pure sugar are heated to 212° C. for one-half hour in a flat-bottomed aluminum dish, the caramel formed is dissolved in boiling water, evaporated to a small volume, and made up to 200 cc with glycerin. The oven for caramelizing the sugar (fig. 6) is constructed as follows:

A and A′ are heavy sheets of asbestos board 18 cm (7 inches) square, A′ being perforated near one edge by a hole for the cork supporting the thermometer *d; b* is a sheet-iron cylinder 15 cm (6 inches) in diameter; *c* is a tin can 9 cm (3½ inches) in diameter, which is filled with paraffin to within 1 cm (1½ inches) of the top. This can rests on the pipestem triangle *e*. The bath or oven is supported on a tripod and is heated by two burners. One burner is so adjusted as to keep the bath at 212° C. when once heated to that temperature.

The oven is brought to 212° C. with both burners. The asbestos cover carrying the thermometer is then removed and 6 grams of sugar, in a flat-bottomed aluminum dish 7 cm (2¾ inches) in diameter and 1.5 cm (⅝ inch) deep, is placed in the can containing the paraffin. The cover is at once replaced and as soon as the temperature reaches 208° C. the second burner is turned out and the bath is kept at 212° C. by the carefully adjusted burner. At the expiration of thirty minutes from the time the sugar was placed in the bath it is removed, dissolved in boiling water, and made up as described. The aluminum dish should not be less than 1.5 cm (⅝ inch) deep, since the sugar melts before caramelizing and runs to one side of the dish, which, if too shallow, will tilt, fill with paraffin, and sink.

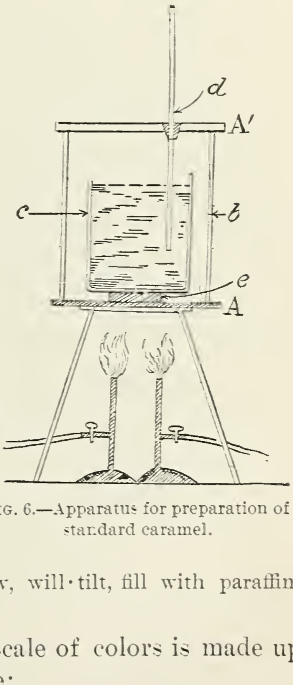

FIG. 6.—Apparatus for preparation of standard caramel.

With the ingredients thus prepared, the scale of colors is made up by mixing as indicated in the following table:

TABLE XVII.—*Amounts of ingredients to be used in preparing solutions for the color scale.*

Color No.	Caramel solution.	Glycerin.	Color No.	Caramel solution.	Glycerin.	Color No.	Caramel solution.	Glycerin.
	Grams.	*Grams.*		*Grams.*	*Grams.*		*Grams.*	*Grams.*
1	0.00	35.00	8	3.50	31.50	15	17.00	18.00
2	.25	34.75	9	4.50	30.50	16	20.00	15.00
3	.50	34.50	10	5.50	29.50	17	23.50	11.50
4	.75	34.25	11	7.00	28.00	18	27.00	8.00
5	1.00	33.00	12	8.50	26.50	19	31.00	4.00
6	1.50	33.50	13	11.00	24.00	20	35.00	.00
7	2.50	32.50	14	14.00	21.00			

It is preferable to use 1-ounce screw-cap vials of perfectly clear glass and of the same internal diameter.

ANALYSES OF SUGAR-CANE JUICES AND SIRUPS.

ANALYTICAL DATA FOR 1903.

The accompanying tables of analyses of cane juices and cane sirups, which were secured during the season of 1903, are submitted with the following explanations:

There were received at the sugar laboratory of the Bureau of Chemistry from W. B. Roddenbery, Cairo, Ga., 16 general juice samples, each representing a day's run, 78 samples of juice from the experimental plats (the data for which are given in connection with the plat work), and 16 samples of cane sirup, each representing a day's run; from the experimental sirup factory at Waycross, Ga., 25 general samples of juice and 22 samples of cane sirup; from O. P. Angelo, Waycross, Ga., 1 sample of cane; from S. L. Lupfer, Kissimmee, Fla., 11 samples of cane.

The large quantity of rain that fell in the early summer drowned out a large part of the seed of the experimental plats at Waycross, so that only a very poor stand of cane was secured, and this made such a poor growth that on some of the plats there was not enough cane for a fair sample. For this reason it was decided not to grind any of this experimental cane, but to save it all for seed for another year.

Both the samples of the general run and those from the experimental plats, are much lower in sucrose, higher in reducing sugar, and lower in purity in 1903 than in 1902.[a] This may have been due in a great degree to the exceptionally wet season. This state of affairs seems to hold good for the Florida canes as well, for while much higher than the Georgia canes, they are much lower than those of 1902.

It will be noticed that the tables of sirup analyses for 1904 differ in several respects from those of 1903. No attempt was made to determine the viscosity for several reasons developed by the work of the preceding year.

The second change is the addition of a second "purity" column. Indeed, the first column might have been omitted, for it is perfectly evident that in a product which has so much reducing sugar, and in which reducing sugar is even desired in order to prevent crystallization, a ratio between the sucrose and all of the other solids present means nothing; but a ratio between the total sugars and total solids shows us at once whether the sirup was properly purified in evaporation, and hence may give an idea of its keeping qualities.

The third change is the addition of a column expressing the per cent of inversion—that is, the per cent of cane sugar inverted in evaporating from juice to finished sirup. This figure serves as a further check on the method of evaporating and the skill with which it is done; for it is evident that a sirup having a very small percentage of inversion will quickly crystallize if evaporated to anything like proper density, and therefore has not been properly treated. On the other hand, if the sirup shows an unusually large inversion, it indicates that the hot sirup remained for too long a time in contact with the heated steam coils without much evaporation, for only thus could an inversion of 30 per cent or over be produced. A reboiled sirup, provided it has not been mixed with any other, could be detected in this way, as well as by the darker color.

The per cent of inversion is calculated by the following formula:

$$\text{Per cent of inversion} = \frac{95\left(R - \frac{r\,(1.05263C + R)}{1.05263c + r}\right)}{C + 0.95\left(R - \frac{r\,(1.05263C + R)}{1.05263c + r}\right)}$$

In which C = cane sugar in sirup.
c = cane sugar in juice.
R = reducing sugar in sirup.
r = reducing sugar in juice.

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[a] U. S. Dept. Agr., Bureau of Chemistry, Bul. 75.

The factor, 1.05263, is used to convert cane sugar to invert sugar, and the factor 0.95 to convert invert sugar to cane sugar. This formula takes no account of the losses during the process of manufacture, but these are relatively very small and can be neglected without seriously affecting the result.

How well these different figures serve to detect or show the character of sirups and their keeping qualities is yet to be determined. Tables XVIII to XXIV give the analytical results obtained in work on juices and sirups from the Waycross and Cairo factories, as well as on a few samples of juice from miscellaneous canes. In Tables XIX and XXII are found descriptions of the samples of sirup at the time of their examination.

TABLE XVIII.—*Analyses of sugar-cane juices from experimental sirup factory, Waycross, Ga., season of 1903.*

Serial number.	Date of sampling.	Total volume of juice.	Density.	Sucrose.	Reducing sugar.	Purity.
	1903.	*Gallons.*	°*Brix.*	*Per cent.*	*Per cent.*	
2833	Nov. 25	1,920	14.8	11.6	1.87	78.4
2835	Nov. 27	1,733	15.5	12.0	2.08	77.4
2937	Nov. 28	1,733	15.8	13.0	1.38	82.3
2839	Nov. 30	1,155	16.3	13.2	1.31	81.0
2843	Dec. 1	1,733	14.9	11.1	2.06	74.5
2850	Dec. 2	2,500	14.7	10.9	1.71	74.2
2852	Dec. 3	2,500	14.3	10.5	1.97	73.4
2855	Dec. 4	1,733	14.0	10.3	2.10	73.6
2865	Dec. 5	2,310	14.3	9.4	2.45	65.8
2868	Dec. 7	2,117	14.8	10.1	1.96	68.2
2874	Dec. 8	2,117	15.0	11.3	1.44	75.4
2883	Dec. 9 and 10	3,675	16.1	12.3	1.17	76.4
2884	Dec. 11	2,695	15.3	11.7	1.67	76.5
2889	Dec. 12	1,350	14.2	10.6	1.10	74.6
2891	Dec. 14	2,500	14.8	10.2	2.36	68.9
2892	Dec. 17	2,887	13.9	11.0	2.20	79.1
2893	Dec. 18	2,213	15.1	11.8	1.57	78.1
2900	Dec. 19	2,020	15.6	10.8	2.47	69.2
2901	Dec. 21	1,733	15.0	10.7	1.81	71.3
2902	Dec. 22	2,310	14.9	11.5	1.22	77.2
2903	Dec. 23	1,733	15.1	11.9	1.08	78.8
2983	Dec. 29	1,925	17.3	12.3	2.60	71.1
2985	Dec. 30	2,117	16.0	11.0	2.07	71.1
2987	Dec. 31	1,251	16.3	11.0	2.56	68.0
2988	do	1,251	16.3	11.0	2.56	68.0
Average		[a] 2,048	15.26	11.23	1.84	73.59

[a] Total number of gallons of juice expressed, 51,411.

TABLE XIX.—*Description of sugar-cane sirups from experimental sirup factory, Waycross, Ga., season of 1903.*

Serial No.	Date of manufacture.	Origin of sample.	Description.
	1903.		
2834	Nov. 25	From juice of same date	Fairly light, cloudy.
2836	Nov. 27	do	Fairly light, clear, one-half inch scum.
2838	Nov. 28	From juice of same date, cane slightly frosted.	Fairly light, clear, one-fourth inch scum.
2840	Nov. 30	From juice cooked to semisirup on November 28.	Fairly light, full of flocks, few very small crystals on bottom.
2842	Dec. 1	From juice of November 30	Dark, clear, one-half inch scum, a number of small crystals on bottom.
2851	Dec. 2	From juice of same date	Fairly light, very clear, a few flocks.
2853	Dec. 3	From juice of December 2 and 3	Dark, fairly clear.
2856	Dec. 5	From juice of December 4	Dark, clear, one-half inch scum.
2866	Dec. 7	From juice of December 5	Dark, clear, one-eighth inch scum.
2867	do	Green cane	Fairly light, clear, one-fourth inch scum.
2869	Dec. 8	Juice of December 7	Dark, clear, few flocks.
2885	Dec. 11	Juice of December 10	Fairly light, clear, one fourth inch scum.
2886	do	Juice of same date	Fairly light, clear, one-half inch scum.
2887	do	Semisirup, filtered	Light, cloudy, one-eighth inch sediment.
2888	do	Semisirup, unfiltered	Fairly light, cloudy, one-half inch scum, one-eighth inch sediment.
2890	Dec. 12	Juice of same date	Very dark, cloudy.
2894	Dec. 14	do	Dark, clear, a few flocks.
2895	Dec. 18	Juice of December 15 and 17	Very dark, clear.

TABLE XIX.—*Description of sugar-cane sirups from experimental sirup factory, Waycross, Ga., season of 1903*—Continued.

Serial No.	Date of manufacture.	Origin of sample.	Description.
	1903.		
2984	Dec. 30	Juice of December 29	Dark, clear, one-half inch scum.
2986	Dec. 31	Juice of December 30	Dark, clear, five-eighths inch scum.
	1904.		
2989	Jan. 1	Juice of December 31	Very dark.
2997	....do...	Sirup made by Plowden, Waycross, from ribbon cane ground in horse mill and cooked in iron kettle over fire.	Very light, rather cloudy, a large number of small and medium crystals.

TABLE XX.—*Analyses of sugar-cane sirups, experimental sirup factory, Waycross, Ga., season of 1903.*

Serial No.	Color.	Total solids.	Moisture (by difference).	Ash.	Sucrose.	Reducing sugar.	Sucrose in total solids.	Total sugar in total solids.	Inversion. [a]
		Per cent.	*Per cent.*	*Per ct.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2834	14	73.9	26.1	1.06	47.48	20.51	64.25	91.82	18.0
2836	14	74.4	25.5	.85	47.48	21.98	63.72	93.17	19.0
2838	16	75.1	24.9	1.00	46.12	25.66	61.41	95.58	28.0
2840	14	75.1	24.9	1.38	55.31	14.79	73.65	93.33	12.2
2842	14	74.8	25.2	1.55	56.82	13.39	76.00	93.86	10.6
2851	16	72.3	27.7	1.06	47.74	19.67	66.03	93.24	17.4
2853	17	75.1	24.9	1.36	42.10	28.11	56.06	93.48	28.1
2856	18	75.1	24.9	1.36	39.82	25.59	53.02	92.41	25.9
2866	17	75.7	24.3	1.21	43.67	24.81	57.68	90.52	18.9
2867	14	74.0	26.0	.92	43.20	25.66	58.38	93.05	....
2869	15	74.0	26.0	1.18	44.45	24.04	60.07	92.55	21.8
2885	15	76.0	24.0	1.61	46.66	21.40	61.39	91.29	24.0
2886	16	75.1	24.9	1.43	43.54	24.42	51.98	90.48	25.9
2887 [b]	......	....	....	....	....	....	....	....	....
2888 [b]	......	....	....	....	....	....	....	....	....
2890	17	77.3	22.7	1.50	25.30	48.08	32.72	94.48	60.8
2894	17	75.6	24.4	1.29	40.47	27.92	53.54	90.40	26.3
2895	20+	73.4	26.6	1.45	35.70	30.77	48.63	94.61	34.6
2984	15	69.5	30.5	1.29	41.74	21.07	60.01	90.33	18.9
2986	17	76.2	23.8	1.40	45.81	24.42	60.13	92.15	21.7
2989	20	78.5	21.5	1.25	32.30	40.10	41.15	92.27	44.0
2997	9	73.8	26.2	.80	63.70	6.70	86.28	96.75	....
Average	16	74.8	25.2	1.27	43.46	25.39	58.10	92.05	25.34

[a] The inversion is calculated by the formula given on p. 66.

[b] Semi-sirups which fermented and were discarded.

TABLE XXI.—*Analyses of sugar-cane juices from factory of W. B. Roddenbery, Cairo, Ga., season of 1903.*

Serial No.	Date of sampling.	Total volume juice	Density.	Sucrose.	Reducing sugar.	Purity.
	1903.	*Gallons.*	*° Brix.*	*Per cent.*	*Per cent.*	
2822	November 20	4,000	16.60	12.90	1.63	77.60
2823	November 21	4,000	16.00	12.40	1.71	77.50
2826	November 23	4,000	16.00	12.95	1.50	81.20
2829	November 24	4,000	17.50	13.00	1.52	74.30
2831	November 26	4,000	16.80	12.95	1.70	77.40
2841	November 27	4,000	16.60	13.20	1.21	79.50
2846	November 30	4,000	15.80	11.90	1.66	75.30
2848	December 1	4,000	16.30	12.80	1.30	78.50
2858	December 2	4,500	15.60	12.45	1.02	80.10
2860	December 3	4,000	15.60	12.00	1.38	76.90
2863	December 4	4,500	16.60	12.60	1.42	75.90
2870	December 5	4,500	15.80	11.80	1.60	74.70
2875	December 8	5,000	16.50	12.00	1.60	72.70
2877	December 9	4,500	14.00	11.30	.95	80.70
2879	December 10	4,500	14.70	11.70	1.16	79.50
2881	December 12	4,500	15.50	11.70	1.07	75.50
	Average	[a] 4,250	16.00	12.35	1.40	77.33

[a] Sum total volume of juice expressed, 68,000 gallons.

TABLE XXII.—*Description of sugar-cane sirups from factory of W. B. Roddenbery, Cairo, Ga., season of 1903.*

Serial No.	Date of manufacture.	Origin of sample.	Description.
	1903.		
2824	Nov. 20	Average of day's run	Dark, clear, a little scum, large medium crystals on sides and bottom.
2825	Nov. 21	Average of day's run; sample of the sirup canned.	Fairly light, full of flocks, layer small crystals on bottom.
2827	Nov. 23	Sample of the sirup canned from day's run.	Dark, cloudy, sides and bottom covered with small crystals.
2830	Nov. 24	....do	Dark, clear, large number of medium crystals on sides and bottom.
2832	Nov. 26	....do	Do.
2845	Nov. 27	....do	Fairly light, rather cloudy, a few small crystals.
2847	Nov. 30	....do	Dark, clear, one-eighth inch scum, large number of crystals.
2849	Dec. 1	....do	Broken in mail.
2861	Dec. 3	....do	Quite light, fairly clear, one-eighth inch scum, layer small crystals on bottom.
2862	....do	....do	Dark, clear, a great many medium crystals on sides and bottom.
2864	Dec. 4	....do	Dark, clear, a few medium crystals on bottom.
2871	Dec. 5	....do	Fairly light, cloudy.
2876	Dec. 8	....do	Fairly light, clear, a few flocks, a few small crystals on sides and bottom.
2878	Dec. 9	....do	Dark, clear, heavy coating of small crystals on sides and bottom.
2880	Dec. 10	....do	Do.
2882	Dec. 12	....do	Do.

TABLE XXIII.—*Analyses of sugar-cane sirups from the factory of W. B. Roddenbery, Cairo, Ga., season of 1903.*

Serial No.	Color.	Total solids.	Moisture (by difference).	Ash.	Sucrose.	Reducing sugar.	Sucrose in total solids.	Total sugar in total solids.	Inversion.
		Per cent.	*Per cent.*	*Per ct.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2824	14	75.7	24.3	0.84	60.50	10.26	80.00	93.33	3.4
2825	13	76.5	23.5	.91	52.27	20.51	68.33	95.14	17.6
2827	14	77.1	22.9	.97	61.86	11.17	80.23	94.17	5.2
2830	14	77.7	22.3	.81	58.76	12.28	75.62	91.44	7.5
2832	15	76.0	24.0	.68	58.01	11.17	76.30	91.03	4.9
2845	14	76.8	23.2	.77	52.20	19.55	67.97	93.31	19.8
2847	14	74.4	25.6	.78	59.80	10.34	80.38	94.31	2.7
2861	15	76.0	24.0	.57	52.95	18.10	69.67	93.55	16.3
2962	16	75.4	24.6	.67	56.87	14.40	75.42	94.49	13.1
2864	14	75.4	24.6	.68	55.81	14.79	74.02	93.69	11.0
2871	14	75.1	24.9	.81	51.70	18.25	68.84	93.14	14.7
2876	13	76.8	23.2	.78	51.58	19.55	67.16	92.61	17.2
2878	13	75.0	25.0	.72	55.86	15.07	74.48	94.59	13.8
2880	14	75.9	24.1	.74	52.93	18.10	69.74	93.58	17.4
2882	14	75.8	24.2	.52	57.06	14.00	75.28	93.75	11.9
Average	14	74.64	25.36	.75	55.88	15.17	73.56	93.48	11.77

TABLE XXIV.—*Analyses of juices from miscellaneous samples of sugar cane, season of 1903.*

Serial No.	Date of sampling.	Density.	Sucrose.	Reducing sugar.	Purity.
	1903.	°*Brix.*	*Per cent.*	*Per cent.*	
2801	October 31	10.9	3.8	2.59	34.8
2788	November 1	14.3	8.2	3.75	57.7
2896	December 23	15.6	12.1	1.66	81.7
2897	.....do	16.8	12.9	1.53	81.2
2898	.....do	12.6	6.3	4.25	50.0
	1904.				
2990	January 4	16.5	12.7	1.03	77.0
2991	.....do	17.4	13.7	1.05	78.8
3000	February 1	15.7	12.1	1.28	77.1
3006	February 15	16.3	13.6	.97	83.4
3007	.....do	17.2	14.7	.77	85.5
3008	.....do	17.9	15.2	.54	84.9
3059	.....do	17.0	14.0	.89	82.3
3060	.....do	16.2	13.2	1.00	81.5
	Average	15.8	11.74	1.64	74.3

ANALYTICAL DATA FOR 1904.

Of the juices and sirups for the season of 1904, the following samples have been analyzed in the sugar laboratory:

Composite samples of juice representing the day's run, from the experimental sirup factory, Waycross	30
Samples of juice from experimental plats, Waycross	29
Samples of juice from experimental plats, Cairo	88
Samples of sirup from Waycross	31
Samples of sirup from Lake Park	8
Miscellaneous samples of sirup	3
Total number of samples	189

Considering the juices of the composite samples from Waycross, by comparing the results for the two years, it appears that the degree Brix of the juice for 1904 is not so high as for 1903, but that the percentage of sucrose and the purity are higher. The 1904 juice should therefore produce more sirup than that of 1903. Unfortunately no record was kept of the amount of sirup produced in 1903, so this point can not be established. Mr. Roddenbery did not send any samples of the day's run of juice, so this figure for 1904 can not be compared with that for 1903, but inasmuch as the juice samples from the cane grown on the experimental plats are much richer for 1904 than for 1903—and Mr. Roddenbery states that he has made 24 gallons of sirup to the ton of cane in 1904—it would seem very probable that all his cane was better than that for 1903.

That 1903 was a very poor year for cane is shown most conclusively by the analyses of the juice samples from the experimental plats (Tables II and VII). The juice for 1904 shows nearly 2 per cent more total solids, over 3.5 per cent more sucrose, 0.35 per cent less reducing sugar, and almost 14 per cent higher purity than that of 1903. The average is most excellent. The unfortunate failure of the experimental plats at Waycross in 1903 prevents a very interesting comparison. The juices yielded by the 1904 canes, while not nearly so rich as the Cairo juices, are still of very good quality. There are no samples of composite mill juices from Cairo for 1904. From Waycross, however, there is a very interesting collection (Table XXV).

The samples of sirup from the day's run show improvement in some particulars over those of 1903. In the first place, notwithstanding the fact that the lightest color for the first eight days was 15, during the rest of the season the color was so good as to bring the general average down to 13.6, as compared with 16 for 1903 (Tables XX and XXVII). The density of the 1904 sirups is slightly greater than of those of 1903, and it will be noted that it is more uniform than for the previous year. The moisture was determined both by difference and by drying, the drying giving, as in previous work, very much higher results. As the solids not sugar present are very small in amount, they ought not to affect the density sufficiently to make so wide a difference in the moisture as appears from the tables. Certain sugars tend to break down and give up some of their combined water on drying, and it seems as if the discrepancy might be due to this cause, especially as in the case of a semisirup, No. 3326, where the sum of the sucrose and reducing sugar is actually greater than the total solids calculated from the moisture by drying. If the total solids from moisture by drying were to be accepted, the purity of the sirup would rise from 92.67, as shown in the table of the analyses of sirups from the day's run, to 98.23, which is, of course, an impossible figure.

The ratio of total sugar to total solids is slightly greater for 1904 than for 1903, as might be expected from the greater purity of the juice from which the sirup is made. The same fact will go far to account for the markedly smaller amount of ash in the 1904 sirups—0.89 as against 1.27 per cent. It will be noted that the sucrose in the sirup has risen from 43.46 per cent in 1903 to 48.11 per cent in 1904, and that the reducing sugar has fallen a corresponding amount—from 25.89 to 21.33 per cent. Also, the per cent of inversion has decreased from 25.34 per cent in 1903 to 17.01 per cent in 1904. These important differences are especially worthy of notice as compared with sirups made in 1902, when the reducing sugar was about the same as in 1903, since they mark the divergence in the methods of evaporation which have been found to produce the greatest inversion, and therefore sirups which will not separate crystals of sucrose on standing.

It has been found necessary to evaporate the sirups much more slowly in order to get the requisite clearness, and it is only too evident that this relatively low heat does not produce the desired amount of inversion, which, as has been shown by experiment, should be about 20 per cent, exceeding that, if anything. The degree of inversion depends also largely upon the natural acidity of the juice—the greater the acidity the greater the inversion. No. 3425 had a coating of crystals on the sides and bottom of the sample bottle, the reducing sugar being only 13.75 per cent. That Nos. 3427 and 3429 did not crystallize is due to the fact that they had 3 per cent less sucrose than No. 3425 and a higher per cent of inversion. None of the other sirups had so little reducing sugar as these three. These facts would be very discouraging if there were no way to produce a larger amount of inversion while making just as clear sirup. The hope of solving the problem lies in the fact that it has been proved to be possible to filter the finished sirup, either hot or cold, so as to leave it perfectly clear and bright. This being so, it will be possible to use the same method of evaporation which gave the good results as concerns inversion in 1903, and at the same time to make a better sirup than heretofore. The added cost of manufacture will be more than compensated for by the increased capacity of the evaporators.

In this connection it is very interesting to compare the analyses of six sirups made at Lake Park (Table XXIX), under the direction of the agent of the Department by the same process of evaporation as at Waycross, and to observe that the results are very nearly the same, the increased purity being due to the greater richness of the cane.

The condition of a semisirup ready to go to the filters is well shown by No. 3326 (Table XXX). A sample of this same sirup after filtering was unfortunately lost. This semisirup shows what a very small amount of inversion takes place in the early part of the evaporation, for notwithstanding the fact that this thin sirup stood for two months before being analyzed, there was still 8.25 per cent of reducing sugars present, and only 5.15 per cent of inversion had taken place.

The study of these analyses makes it evident that the ideal sirup should be one of a color at least as light as 14, since color is dependent to a very large extent upon the cane itself rather than upon the evaporation; it should have from 20 to 30 per cent of reducing sugar, but not more, since a greater amount is evidence of excessive acidity, either in the juice or the semisirup, and it might be better to limit the reducing sugar to 26 on this account; it should have a ratio of at least 95 of total sugars to total solids, and as much higher as possible, which would indicate at least 42 per cent of sucrose, with a maximum of 52 per cent; it should be perfectly clear and brilliant. The work thus far would seem to indicate that it may be necessary to filter the sirup after it has stood long enough in the cold to separate all the flocculent matter which it contains, although there have been produced one or two samples which were clear when hot, and remained so when cold. It may prove possible to produce such sirups with certainty.

The analytical work following was performed by Mr. C. G. Church and Mr. Martin Boyle, of the Sugar Laboratory, Bureau of Chemistry:

TABLE XXV.—*Analyses of sugar-cane juices from experimental sirup factory, Waycross, Ga., season of 1904.*

Serial No.	Date of sampling.	Volume of juice.	Density.	Sucrose.	Reducing sugar.	Purity.
			° *Brix.*	*Per cent.*	*Per cent.*	
3324	November 3	2200	14.40	10.95	2.23	76.40
3227	November 4	2760	14.40	10.15	2.37	70.30
3334	November 5	3100	14.50	10.90	2.10	75.20
3341	November 7	3400	15.10	11.60	2.07	76.80
3344	November 8	3400	14.80	11.10	1.98	75.00
3346	November 9	3145	14.20	10.20	2.43	71.80
3349	November 10	3700	15.30	11.90	2.13	77.80
3351	November 11	2800	13.20	7.45	3.37	56.40
3353	November 12	2800	14.30	10.20	2.84	71.30
3366	November 14	3150	16.10	13.10	1.65	81.40
3370	November 15	1500	17.10	14.45	1.63	84.80
3372	November 16	4170	13.90	8.45	3.30	60.80
3374	November 17	4250	16.10	12.35	1.66	77.00
3376	November 18	3900	13.90	9.68	2.94	69.80
3391	November 19	2600	15.80	12.95	1.72	82.30
3410	November 21	4250	14.70	11.08	2.28	75.50
3418	November 22	3515	16.10	12.95	1.77	80.70
3420	November 25	3885	16.50	12.72	2.07	77.00
3422	November 26	3800	16.80	13.86	1.88	82.70
3424	November 28	1950	17.10	14.20	1.53	83.00
3426	November 29	4100	17.00	14.07	1.45	82.90
3428	November 30	1650	16.70	13.95	1.38	83.80
3431	December 2	3150	15.90	12.35	1.86	78.00
3433	December 3	2400	14.70	10.02	2.83	68.20
3435	December 5	3700	14.70	9.94	2.74	67.60
3441	December 6	2775	16.80	12.22	2.53	72.70
3443	December 8	3330	15.60	11.77	1.62	75.60
	Average	[a]3162	14.95	11.65	2.18	77.93

[a] The sum total of juice expressed was 85,382 gallons.

TABLE XXVI.—*Description of sugar-cane sirups from experimental sirup factory, Waycross, Ga., season of 1904.*

Serial No.	Date of manufacture.	Origin of sample.	Description.
3315	Oct. 17	First run of season	Dark, muddy, three-eighths-inch sediment.
3316	....do...	First run of season: evaporated on Porter evaporator.	Almost entirely crystallized.
3325	Nov. 3	First regular run	Dark, clear, one-half-inch sediment.
3326	....do...	Unfiltered semisirup	Light, muddy.
3328	Nov. 4	From juice of same date	Rather dark, clear, with flocks.
3335	Nov. 5	.....do	Fairly light, rather muddy, one-fourth-inch scum.
3342	Nov. 7	.....do	Do.
3345	Nov. 8	.....do	Do.
3347	Nov. 9	.....do	Darker than No. 3335, otherwise same.

TABLE XXVI.—*Description of sugar-cane sirups from experimental sirup factory, Waycross, Ga., season of 1904*—Continued.

Serial No.	Date of manufacture.	Origin of sample.	Description.
3350	Nov. 10	From juice of same date	Darker than No. 3335, otherwise same.
3352	Nov. 11		Clear, light, one-fourth-inch scum.
3360	Nov. 14	From juice of November 12	Quite light, muddy, three-eighths-inch scum.
3367	do		Do.
3371	Nov. 15		Do.
3373	Nov. 16		Darker, one-fourth-inch sediment.
3375	Nov. 17		Broken in mail.
3377	Nov. 18		Dark, one-fourth-inch sediment.
3402	Nov. 21	Juice of November 19	Muddy, full of flocks, one-eighth-inch scum.
3411	do		Clear, flocculent, one-eighth-inch scum.
3419	Nov. 22		Light, clear, one-half-inch scum.
3421	Nov. 25		Cloudy, light, one-fourth-inch scum.
3423	Nov. 26		Light, cloudy, three-eighths-inch scum.
3425	Nov. 28		Light, slightly flocculent, one-half-inch scum, full coating small crystals on bottom, a few on sides.
3427	Nov. 29		Light, slightly flocculent, one-half-inch scum.
3429	Nov. 30		Do.
3432	Dec. 2		Light, clear, and brilliant, one-fourth-inch scum.
3434	Dec. 5	Sirup from red cane	Light, clear, and brilliant.
3437	do	From green cane juice	Darker than No. 3434, otherwise the same.
3440	Dec. 6	Red cane juice, first mill only	Very light, very clear, and brilliant, a few flocks near top.
3444	Dec. 8	Sirup from ribbon cane which had started to grow again.	Darker than No. 3440.

TABLE XXVII.—*Analyses of sugar-cane sirups from experimental sirup factory, Waycross, Ga., season of 1904.*

Serial No.	Color.	Total solids.	Moisture.		Ash.	Sucrose.	Reducing sugar.	Total sugar in total solids.	Inversion.
			By difference.	By drying.					
		Per cent.	*Per cent.*	*Per cent.*	*Per ct.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
3325	16	74.94	25.06	27.72	0.78	52.59	18.60	95.00	5.69
3328	16	75.49	24.51	28.47	.80	47.90	23.31	94.33	16.45
3335	16	74.55	25.45	28.44	.87	46.07	25.14	95.51	22.27
3342	16	74.38	25.62	29.17	.69	33.97	35.78	93.75	41.53
3345	15	77.52	22.48	25.66	.73	45.65	25.99	94.86	23.32
3347	17	72.60	27.40	30.43	.70	39.82	28.28	93.81	26.77
3350	16	76.04	23.96	27.24	.80	48.88	19.93	90.49	15.90
3352	16	77.35	22.65	27.97	1.87	43.05	26.81	89.02	32.14
3360	11	74.89	25.11	28.46	1.00	44.11	24.04	91.00	16.68
3367	11	75.43	24.57	27.64	.93	52.02	17.52	92.19	15.17
3371	9	75.43	24.57	28.85	.89	36.70	32.19	91.33	39.61
3373	13	74.89	25.11	29.02	.84	43.70	25.22	92.02	11.45
3377	14	73.77	26.23	29.00	.82	44.00	24.81	93.27	16.09
3402	13	76.56	23.44	27.34	.78	45.85	25.30	92.93	26.11
3411	14	74.89	25.11	28.75	.78	50.09	19.28	92.62	12.09
3419	12	74.49	25.51	28.36	.69	53.20	16.40	93.44	12.71
3421	12	73.93	26.07	29.85	.71	51.83	16.47	92.33	11.32
3423	12	76.28	23.72	26.94	.78	51.94	17.72	91.32	14.75
3425	12	75.40	24.60	25.94	.87	58.38	13.75	95.65	9.66
3427	12	75.71	24.29	28.23	.93	55.73	13.45	91.38	11.03
3429	12	75.16	24.84	28.13	.81	55.65	13.30	91.74	10.66
3432	13	74.61	25.39	27.78	.93	54.10	15.08	92.72	9.62
3434	15	74.05	25.95	29.08	.88	49.60	18.49	91.95	4.12
3437	15	74.61	25.39	29.07	.90	43.73	24.50	91.45	8.17
3440	11	74.38	25.62	28.73	1.15	54.25	15.63	93.95	16.52
3444	16	74.00	26.00	28.73	1.23	51.91	15.89	91.62	12.48
3603	13	74.00	26.00	28.98	.81	44.26	24.04	92.30	....
Average	13.6	75.01	24.99	28.29	.89	48.11	21.33	92.67	17.01

TABLE XXVIII.—*Description of miscellaneous sugar-cane sirups from factories at Lake Park and other points in Georgia, season of 1904.*[a]

Serial No.	Date of manufacture.	Origin of sample	Description.
	1904.		
3430	Nov. 28	W. B. Roddenbery, Cairo, Ga..........	Light, cloudy, and very flocculent, one-eighth-inch scum.
3442	Dec. 7	Manor Trading Co., made on Cook evaporator over fire.	Very light, very clear, and brilliant, one-eighth-inch scum.
3485	....	J. T. Wells, Guyton	Light, very full of flocks, one-eighth-inch sediment.
3589	....	West, Holmes, and Coffee, Lake Park; sirup of 1903.	Very dark, clear, and brilliant.
3590	Dec. 27	West, Holmes, and Coffee, Lake Park.	Light, somewhat cloudy, otherwise clear and brilliant.
3591	....	.....do	Do.
	1905.		
3592	Jan. 3	West, Holmes, and Coffee, Lake Park.	Light, somewhat cloudy, otherwise clear and brilliant.
3593	....do ...	.....do	Do.
3594	....do ...	.....do	Light, somewhat cloudy, otherwise clear and brilliant, with one-eighth-inch scum.
3595	....do ...	.....do	Light, somewhat cloudy, otherwise clear and brilliant.
3599	Jan. 20	J. W. Butler, Lake Park...............	Dark, clear, and bright.

[a] See Tables XXIX and XXX for analyses.

TABLE XXIX.—*Analyses of sugar-cane sirups from Lake Park, Ga., season of 1904.*

WEST, HOLMES, AND COFFEE.

Serial No.	Color.	Total solids.	Moisture.		Ash.	Sucrose.	Reducing sugar.	Total sugar in total solids.
			By difference.	By drying.				
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
3589......	18	79.60	20.40	24.22	1.25	50.02	23.74	92.66
3590......	14	74.00	26.00	29.47	1.35	51.00	16.44	91.13
3591......	14	74.00	26.00	29.23	1.16	49.79	18.86	92.76
3592......	13	68.87	31.13	33.92	.86	47.75	16.30	96.72
3593......	15	76.22	23.78	26.53	1.02	51.87	19.83	94.07
3594......	14	74.00	26.00	28.92	.97	49.64	19.43	93.34
3595......	15	76.79	23.21	26.88	1.14	50.47	20.24	92.08
Average .	14.2	73.98	26.02	29.16	1.08	50.09	18.52	93.35

J. W. BUTLER.

3599......	17	71.65	28.35	31.61	0.99	49.49	16.58	92.21

TABLE XXX.—*Analyses of miscellaneous cane sirups, 1904.*

Data.	Serial No.	Color.	Total solids.	Moisture.		Ash.	Sucrose.	Reducing sugar.	Total sugar in total solids.
				By difference.	By drying.				
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Unfiltered semisirup from Waycross factory..........	3326	9	41.75	58.25	71.93	0.45	30.35	8.25	92.54
Sirup from factory of W. B. Roddenbery..............	3430	12	76.85	23.15	24.94	.73	54.10	15.08	92.72
Sirup from Manor Trading Co., Manor, Ga	3442	10	74.66	25.34	27.90	.60	51.76	17.48	92.24
Sirup from J. T. Wells, Guyton, Ga	3485	13	77.35	22.65	26.49	1.14	39.42	33.74	94.58

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